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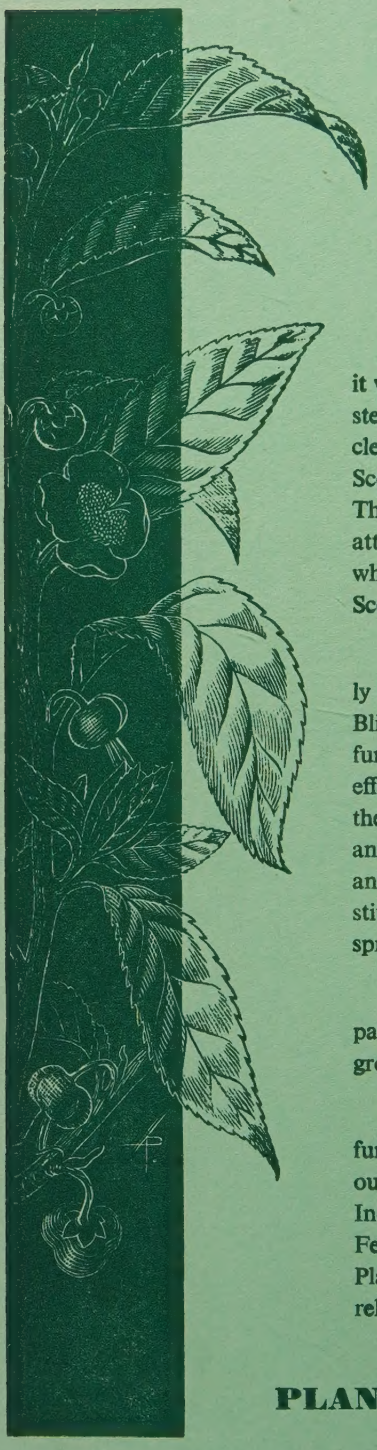

After Coffee...

TEA

Before Ceylon became famous for its tea, it was famous for its coffee. Early in the 1800s the steep green slopes of the island's hill jungle were cleared and cultivated by coffee planters, mostly Scots, and coffee soon became the major crop. Then in 1869 came disaster : a devastating blight attacked the trees and within a few years the whole industry was wiped out. So the resourceful Scots planted tea instead . . . .

But the tea bushes of Ceylon have constantly to be protected against diseases—among them Blister Blight. Here the problem was not to find a fungicide—a copper compound was known to be effective—but to develop a technique of spraying the bushes so that the fungicide could penetrate and do its job. Plant Protection Ltd was called in and, in collaboration with the Tea Research Institute, they evolved a technique of low-volume spraying which proved completely satisfactory.

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Some Problems of Agricultural Broadcasting

With Special Reference to B.B.C. Overseas Programmes

HILARY PHILLIPS

Overseas Agricultural Talks Producer, British Broadcasting Corporation

It is a well known fact that farmers everywhere like talking shop. This perhaps accounts for their enjoyment of farm radio and television programmes. However, farm radio has its problems. This article concerns some of the problems of broadcasting agricultural programmes to overseas countries. First to get the perspective, it is necessary to examine agricultural broadcasting within a single country. In Britain farm programmes are very popular with the agricultural community. A recent audience research survey carried out by the BBC in the Western part of England found that the BBC West Region programme *The Farmer* was attracting almost as many listeners in the farming community as *Take It From Here* and other well known programmes, and that in appreciation of content it ranked near the top of the list.

In certain circumstances, too, farm programmes can be devised which will interest the town listener as well. Thus the London programme *Farm Fare* has an audience of more than half a million people every week, and an ' appreciation index ' considerably above the average for all programmes. Here then are two programmes which command large and appreciative audiences; others could be quoted—notably Scotland's *Farm Forum*—but to simplify the issue, I shall concentrate on *The Farmer* and *Farm Fare*.

UNITED KINGDOM PROGRAMMES

The producer of *The Farmer* (in Bristol) knows that his audience is still fairly close to the soil. Consequently he is able to keep his programme strictly to farming, with talks and discussions aimed directly at farmers. While the programme remains at its present high standard, therefore, the producer should have no difficulty in holding his audience—at any rate not until farmers are offered a regular television farm programme at the same time. In *Farm Fare*, on the other hand, the position is vastly different. This programme is broadcast every week in the BBC London, Midland and Welsh Regions and alternate weeks in the North Region. Its audience usually exceeds half a million; yet there are in England and Wales only about 300,000 farmers, so that even if every single one of them listened to *Farm Fare* the programme would still have 200,000 listeners with no direct interest in farming.

How then, has this big audience been built up ? In this case, by the inclusion in the programme of a good deal of material of direct interest and appeal to the town housewife. The price of bacon, the quality of home-produced eggs compared with imported, and the most desirable

composition of milk are typical subjects. Further, many topics which are introduced into this programme are controversial, or quickly become so within a few moments of their introduction. Full rein is given to unscripted discussion, with frequent interruptions by any one of the three or four people taking part. A favourite gambit is to introduce an expert and then have him torn to pieces. The other day I heard a man say ' I don't know a thing about farming, but I always listen to *Farm Fare*; you can be sure of a good row '.

The difference of approach made by these two equally successful programmes is this. *The Farmer* addresses itself exclusively to farmers (and horticulturists). If it is not as technical as a trade paper, it is at least as technical as the agricultural column in a good newspaper. *Farm Fare*, on the other hand, carries its share of technical material, but it acknowledges the presence of large numbers of listeners with no knowledge of farming by, as it were, making a number of leading asides for their benefit.

No summary of farm broadcasting anywhere should omit reference to *The Archers*. This is not a farm programme: it is ' an everyday story of countryfolk ', but it has, as its central character, Dan Archer, a farmer, and for fifteen minutes every weekday (with a sixty minute summary on Saturdays) between eleven and twelve million listeners in Britain follow the daily occurrences in the imaginary village of Ambridge. Obviously a programme with this enormous audience can be, and has been proved to be, a valuable vehicle for the conveyance of agricultural news and new ideas of service to the farmer.

Here it is worth noting that *The Archers* does not enjoy the same undivided popularity overseas. The half hour overseas edition broadcast from London every week is keenly enjoyed by some listeners and almost as keenly disliked by others: ' I wish you would bury all the Archers ' was a typical comment that I once heard. Many overseas listeners are nonplussed by some of the references in the programme to people or events whose significance is not great outside our own islands. Indeed to my mind it is in its concentration upon domestic affairs that the strength of *The Archers* lies, so far as home broadcasting is concerned. It is the same with farm programmes. Farmers everywhere are mostly parochial, and not international, in their interests and outlook. In order to serve the farming community, farm programmes of a technical or semi-technical type must offer something which is of direct practical significance and applicable to local conditions. This is the great problem of overseas agricultural broadcasting, *i.e.* farm programmes broadcast from London to people in overseas countries. Or rather, this is one of the great problems. There are others and in combination they make a formidable array.

PROBLEMS OF OVERSEAS PROGRAMMES

First: discussing *Farm Fare* I pointed out that the producer had had to reshape his programme in order to provide a meal to suit many tastes; but at least all of his listeners are British and his farming listeners enjoy reasonably common interests. In the English-speaking part of the External Services of the BBC the only common factor is language. That is not to say that the BBC does not broadcast farm programmes in other languages: it

does. However, an examination of farm programmes in English serves well enough to illustrate the problems encountered.

The biggest difficulty is to find a programme which is likely to be acceptable to farmers everywhere—to the sheep station owner in Australia, the dairy farmer in Kenya or the smallholder in the West Indies. One solution is to produce a programme with a mixed bill of fare so that the listener may take his pick. This is effective with the printed word, where the reader can be selective, but whereas a number of farmers may buy a particular trade magazine for different reasons and each of them may confine his attentions to a different part of the periodical, the radio listener must endure everything, even if he suspects that the item he wants to hear about is at the end of the programme. Thus either the mixed programme must contain much material of interest to a limited section of the audience or else it must exclude a great deal of useful material and concentrate only on subjects in which a common interest can be found.

The main agricultural programme of the Overseas Service of the BBC, *Land and Livestock*, began with the intention of providing listeners throughout the world with a truly international mixture of agricultural news and views. London, it was rightly argued, was well placed for such a venture and often this programme carried in a single half hour topical reports of events as far apart as the Rand Easter Show and the Sydney Royal. The agricultural news bulletin carried news of such things as floods in New South Wales, drought in Texas, the activities of the Food and Agriculture Organisation of the United Nations and important British livestock sales.

The programme was to this extent unique. No other programme in the world contained so much up to date agricultural information from every quarter of the globe. For a farming intelligentsia such a programme had everything to commend it. However, in one sense it was this very fact which was its weakness. Although farmers everywhere like talking shop and meeting farmers from other countries, this is only true for as long as they can find a common ground for discussion. It is not possible for this common ground to be maintained in the space of a weekly half hour programme broadcast to every part of the world.

However, there is one exception to this rule. Farmers everywhere still seem to be interested in British agriculture, even where their own farming differs considerably from ours. British livestock and agricultural machinery are familiar throughout the world and British advances in agricultural science—in obvious fields like weed and insect control, and less obvious, such as grassland research—are followed with interest by agriculturists everywhere.

Interest in British farming events can, then, be considered a world-wide common factor. For this reason, the General Overseas Service still broadcasts one programme every week, *Five Minutes for Farmers*, which can be heard in most parts of the world. This programme, as its title implies, is very short and takes the form of a single talk or interview. The subject matter is always topical British agricultural news. This programme has the added advantage that its brevity reduces the irritation to non-agricultural listeners. It can also be incorporated easily into longer magazine programmes arranged by broadcasting organizations in other countries.

It seemed that the best way in which to serve the varied needs of listeners in different parts of the world was to break the *Land and Livestock* programme up into different editions, and a beginning has been made on these lines. Since April 1954 a fifteen minute magazine programme designed for people farming on European lines in East, Central and South Africa and a separate fifteen minute programme for farmers in New Zealand and Australia have been broadcast every week. North America is not a main target area for this programme and therefore the edition designed for Australia and New Zealand is carried by the North American Service. The North American Service broadcasts a weekly programme, specially designed to suit the American listener, *Farm Life in Britain* which is about British agriculture. This process of regionalization has now been carried a stage further. On 16 October the first West Indian edition of *Land and Livestock*, again a fifteen minute magazine, was broadcast and this programme is at present scheduled on a monthly basis.

These three fifteen minute editions of *Land and Livestock* have the same magazine structure in common, each programme consisting of three, or sometimes even four, separate subjects linked by the narrator. This is necessary because even when the programme has been regionalized so that, for example, only half of Africa is the target, this area itself includes such a wide diversity of types of farming that it is inevitable that the listener should be offered a mixed fare. It is hoped, however, that the mixture is as a whole more to the listeners' taste than was possible before regionalization. The alternative would be to choose a particular subject of interest only or largely to Kenya, for example pyrethrum, in one week, and then to choose another subject like tobacco in the following week for the benefit of Rhodesia and Nyasaland and South Africa. Theoretically, this would be possible, but it would involve careful advance billing of programmes in *London Calling*, the weekly journal of the BBC Overseas Service, which goes to press six or seven weeks ahead of its delivery date, and the programme would, of course, cease to be of interest to regular listeners.

REGIONAL PROGRAMMES

The best solution, therefore, seems to be regional magazine programmes offering a mixture of items which are broadly similar in their slant, supplemented at intervals by special agricultural programmes. Some examples of the latter are *Farmers' Safari*, an African agricultural travelogue and *Caribbean Farm Journey*, a similar type of programme. These two programmes contained the recorded voices of many agricultural experts and farmers, and were presented as documentaries. *Blood Will Out*, a programme about British livestock, was presented in a similar form. Sometimes, a straight talk will prove more effective. Certainly there should never be a hard and fast rule about the method of presentation. In *Story of a Mission*, LAURENS VAN DER POST talked for half an hour about the mystery and wonder of the Kalahari, unaided by any device except his own narrative powers.

With a regional magazine programme designed for a particular part of the world it is much easier than in the case of an international programme to provide material which can be of service to the listener. Australian farmers are interested to hear what a well known Australian cattle man

thought of the Shorthorn or Aberdeen Angus champion at Perth, the New Zealand grassland expert (unsurpassed at his job though he may be) has a great respect for the opinions of Dr W. Davies, Director of the British Grassland Research Institute. South African egg producers can eavesdrop on a repeat of a Home Service discussion between the Chairman of the South African Egg Board and three British egg producers.

In the West Indian edition, the small farmer in British Guiana can hear about progress of the 4 H Club movement in Jamaica, a matter of special concern to him since this movement is now beginning in his own country. Here, the service provided by a programme like *Land and Livestock* can be wider than the service provided in its African and Pacific editions. In part it can serve as a West Indian Federal Farm programme, keeping several parts of the Caribbean in touch with each other's agricultural developments. Again, if Rothamsted is asked to send a man to Trinidad to investigate red ring disease of coconuts, then it is of interest to many parts of the West Indies to hear him discussing his findings.

There is another difference between the West Indian edition of *Land and Livestock* and the other two editions of this programme: it deals with tropical agriculture directed towards the small peasant farmer, as opposed to the European type of farming aimed at the white farmer in Africa or Australasia. The farmer in the Caribbean is often semi-illiterate and his agriculture is technically far less advanced than that of the farmer in, say, New Zealand or Kenya. Therefore a programme for the West Indies must be simple and more didactic in form. The radio listener can never switch back to the part he has missed. It follows that where he is unlikely to refer to the printed word to check his facts there must in the radio programme be greater recapitulation and greater emphasis on the individual points to be made.

In the more typical European or American type of programme, on the other hand, the important point is to make the listener sufficiently interested to want to learn more by reference to the textbooks or farming periodicals or by asking his local extension officer. In broadcasts to undeveloped areas this object is still paramount but allowances must be made for the fact that the listener may not be able to read and extension officers may be scarce. For this reason the Department of Agriculture in British Guiana places great value on its own weekly farm programme broadcast by the Government Information Service.

At present, the West Indies is the only part of the world to which a BBC farm programme concerned with tropical agriculture is regularly directed. Other parts of the tropical world could be served in a similar way, but there are a number of difficulties. In most cases programmes would have to be translated into the local language and it would be difficult to provide programmes which were suitable for more than one territory. However, these problems might be overcome. The Colonial Office has already cooperated with the BBC by providing useful information on the attitude of the departments of agriculture in Colonial territories to agricultural broadcasts. One way in which the BBC might help would be to provide recorded talks by world authorities on particular subjects, each talk then being used by a broadcasting organization in a Colonial territory as a basis for a wider programme

in which the authority's expert view could be amplified or modified by the local agricultural expert or farm radio producer. Here again, it would not be within the resources of the BBC to produce a large number of talks on widely differing subjects which were themselves suited only to a very limited area. The task would be to provide material which was of interest to a number of different territories and yet, paradoxically, especially suited to each one of them.

PRESENTATION OF FACTS

It is probably true of all farm programmes everywhere to say that the actual method of presenting the facts is one of the hardest problems to overcome. On the whole farmers are not good listeners unless they are convinced that the man really knows what he is talking about and can talk practical common sense. Nine times out of ten, this means, as far as they are concerned, that he must be a farmer himself, or at any rate have ' mud on his boots '. It is generally difficult to find agricultural scientists who are acceptable to farmers as broadcasters. Interviews recorded in the field can help here, since they add a touch of reality to the subject being discussed, and in certain cases farm advisory workers make good broadcasters. It is worth noting, though, that a survey carried out in the United States among a section of farm listeners rated farmers as the most popular type of broadcaster, with extension agents second, and farm radio commentators at the bottom of the poll. There are, of course, exceptions to this, witness Ralph Wightman, who is as popular among farmers in the West Country of England as he is with townsfolk.

Apart from choice of speakers, the type of presentation is also of great importance. The field interview has been mentioned, and where the expert being questioned is able to talk lucidly about the subject, there is probably no better method of presenting the information. Here much depends upon the skill of the interviewer in leading the discussion so that each point is made in logical sequence, but without obtruding his personality. One of the greatest pitfalls of radio interviewing is for the interviewer to imagine that it is his witty remarks upon which the listener hangs. The listener, naturally, wants to hear the expert answering the same sort of questions that he himself would put if he had the chance. If the interviewer incurs his resentment he will retaliate by switching off.

There is at present a vogue in favour of unscripted rather than scripted treatment of the subject, which as a rough guide I favour myself. But while most men will talk about their work better in the field, rather than in the stuffy broadcasting studio, there are exceptions. Sometimes a script is the best method, but the moment a script is introduced it becomes essential to introduce with it the artificial tricks of the trade, with which regular broadcasters are familiar, in order to create the ' fireside chat ' type of atmosphere. This can be carried too far, so that a kind of inane familiarity-*cum*-condescension creeps into the speaker's delivery.

The speaker himself is the key to the problem. If he really knows what he is talking about, then, scripted or no, he will probably carry conviction. If the subject matter is really good, the listener is willing to be tolerant.

No mention has yet been made of what, to many, must be the most

obvious question—how can the farmer overseas actually hear the programmes broadcast from London, what about poor reception and is his radio capable of receiving London at all ? Some farmers can, if they wish, listen to London direct, that is to say their radio sets are capable of picking up the transmissions. Often this has been found to be the case when they have themselves stoutly denied that it was possible. Nevertheless, personal experience in parts of Africa and in the West Indies has shown me that while farmers are willing to tune in to London for special programmes occasionally, they ordinarily prefer to leave their receiver tuned to the local broadcasting station of their choice. In most cases, the small peasant farmer has no alternative. His receiver will pass on to him what the local broadcasting station chooses to broadcast and nothing more.

It follows therefore that BBC farm programmes must reach the listener overseas through the networks of the broadcasting stations of the various countries to which they are directed. Thus, the goodwill of the re-broadcaster is a pre-requisite and without his cooperation, much of the material broadcast from London would not reach the listener.

Where there is no local farm programme, a re-broadcast of a BBC farm programme may be arranged by a broadcasting service overseas. Often, though, this organization may already have a farm programme of its own. In Australia, for instance, the Rural Broadcasts Department of the Australian Broadcasting Commission is very active and highly developed. Naturally, the staff of this department can provide a much more suitable framework for their own agricultural material than the BBC could provide from London. Alternatively, the BBC can and does, through its programmes, provide talks and interviews which merit inclusion in the farm programmes of Australia and many other countries. *Five Minutes for Farmers* fits comfortably into magazine programmes without alteration, and *Land and Livestock* can easily be dismembered so that individual items may be re-broadcast.

The mechanics of this are simple in theory but the reverse in practice. In theory a transmission from London can be recorded at the receiving end by the broadcasting station of the country concerned and the local radio producer can then select for his own use the item or items which he prefers. Often however, the lack of recording facilities at the appropriate time, or poor reception conditions, prevent this from being possible. As a supplement, therefore, to its shortwave programmes, the BBC selects a number of talks from *Land and Livestock* every year and these are recorded and distributed on records to broadcasting organizations which request them. In my own personal view this system has everything to commend it where the listener in the country concerned has a local broadcasting service which will in all probability give him good reception conditions. In such circumstances the alternative shortwave programme from London will probably reach him only through the medium of a re-broadcast in any event.

One disadvantage of the present series of agricultural talks distributed in this way by the BBC's Transcription Service is that topicality is lost and for this reason many subjects which would otherwise be suitable for recording have to be rejected. It is known that many people in charge of farm programming overseas wish that topical material could be distributed on tapes by air mail to would-be re-broadcasters. But there is a limit to the extent to

which the BBC can legitimately engage in the conveyance of material by ways other than its real job of wireless broadcasting. Consequently this other development does not at present seem likely to occur.

SUMMARY

The main problems of overseas agricultural broadcasting are: a substantial part of the subject matter of the programme must be of direct use to the farmer; it must present topics which can be covered better from London than in the country concerned; it must be presented in a way which is acceptable to farmers in the part of the world to which it is directed and, above all, by some means or other the difficult route from the studio in London to the receiver in the farmer's home overseas must be navigated.

(*Received October 1956*)

Agriculture in Central Persia

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Department of Agriculture, University of Oxford

This description of the general pattern of agriculture in Central Persia is based upon part of the work of an Oxford University expedition to Kerman during July to early September of 1950. The Kerman basin was selected for study because it was thought to show a pattern of settlement and occupation typical of the central plateau.

PHYSICAL AND SOCIAL BACKGROUND

The high plateau of Central Persia, 3–4000 ft above sea-level in the north and west, 1000 ft in the south east, is surrounded by mountains. The broad Zagros range in the west and south west, and the Elburz and Kopet Dagh ranges in the north, effectively intercept most of the rain-bearing winds, so that the 10 in. isohyet lies along the inner edge of the mountains. There is no appreciable drainage outwards from the plateau. Water from seasonal streams and percolating ground water therefore evaporates where it accumulates at the lowest point in each basin, to form the great salt wastes of the Dasht-i-Kavir and Dasht-i-Lut in the north and east of the plateau. Two ranges roughly parallel to, and west of, the Zagros range divide the western part of the plateau into two chains of basins, running north west to south east, of which the lowest parts contain *kavir* or salt desert. The Kerman basin lies at the south end of the eastern chain.

Climate—Temperatures in the Kerman basin are extreme and the mean annual precipitation (5·89 in.) is low[1]; (see *Table I*).

Table 1. Meteorological records for Kerman

Condition	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
Mean precipitation in.* ..	0·5	0·9	0·8	0·7	0·1	0·2	0	0	0·1	0·1	0·5	1·4
Mean maximum temp. F° ..	58	60	65	77	91	101	101†	98	92	85	73	58
Mean minimum temp. F° ..	27‡	31	38‡	47	56	65	65	59	51	42	33	30
Mean relative humidity % ..	63	58	58	49	35	30	34	33	41	47	51	67
*Calculated transpiration from a continuous crop cover in.*** ..	1	1	2·5	4	5	5·5	5·5	5	4	2·5	1	1

* Calculated for a shorter period than mean of annual totals [1]
† Absolute maximum, 1909–15: 112°F
‡ Absolute minimum, 1909–15: January 7°F; March 5°F
** By the method of H. L. Penman

Much of the precipitation through December to March is in the form of snow. Frosts are expected in November and continue into March, occasionally causing damage in April and May.

Precipitation is higher in the high valleys and mountain basins than on the plain. Temperatures are more extreme, the growing season is therefore shorter.

Relief—The town of Kerman with its suburban villages is situated at the foot of an isolated rocky crag, at the north west corner of the plain (see

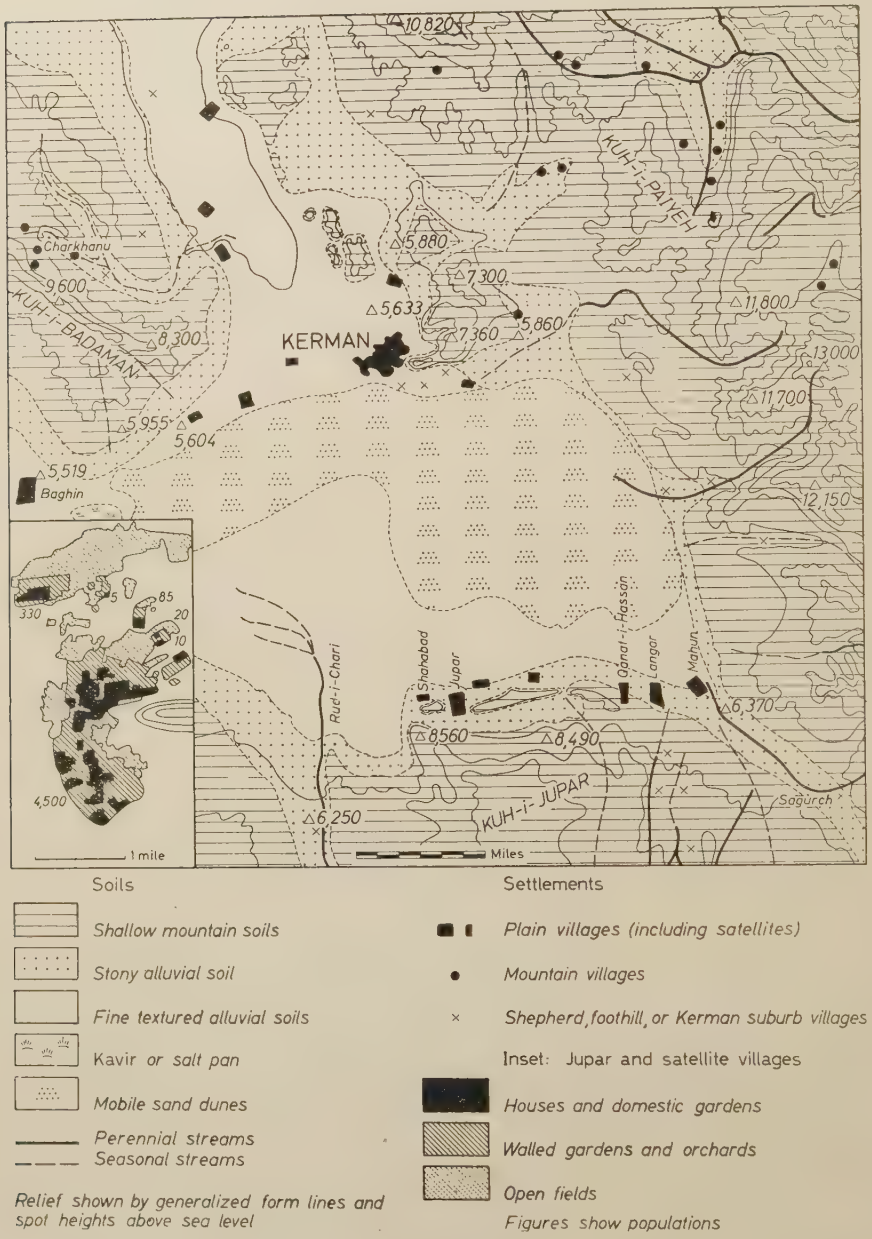

Figure 1

Figure 1). The plain (about 5–6000 ft above sea level) is cut off from the south and east by blocks of mountains up to 13,000 ft high, and to the north west by a lower range up to 9600 ft, all of which rise steeply from a broad band of stony outwash, and are nearly bare of vegetation. Frequent dry

valleys lead from the plain on to high stony table-lands, of which some provide shelter and water for settlement.

Further from the mountains the stony outwash is succeeded first by stony sandy loam, and finally by light-textured alluvial deposits of sandy loam, and fine sandy loam, in a more or less regular succession. There are no large salt-flats in the Kerman plain; lateral flow into local depressions has caused one small pan near Baghin, and small patches of slightly saline *solonchak* soils in other places.

In general the distribution of major settlements on the plain is closely correlated to the intensity of the ground water flow. The heaviest settlements have taken place at the foot of the highest surrounding ranges which have the greatest catchment areas. Most of the larger settlements occur at the mouths of the larger valleys, *e.g.* Kerman and Mahun. In the south a low conglomerate ridge has dammed the ground-water derived from the lofty Kuh-i-Jupar, and a number of large villages are situated opposite the gaps in the ridge. There is a large group of settlements near Jupar, where the percolating water spills round the termination of the ridge. Because of its high banks and narrow valley the only perennial river (Rud-i-Chari) waters only two villages in the area before it becomes lost below the sands. Minor settlements in the mountains and foothills are always sited close to a spring or perennial stream.

Irrigation water—The ground water below the gravel fans varies in quality. Measured salt contents gave: sodium 1 to 10 m equiv./l.; magnesium 1 to 6 m equiv./l.; calcium < 1 to 1 m equiv./l. The water takes up more salts as it percolates beneath the plain, so that generally speaking water from *qanàts* (see p. 12) tapping ground water below the gravel fan is less saline than water from wells in the finer alluvial deposits (*cf.* sodium 15 m equiv./l.; calcium 8 m equiv./l. from a well).

Soils—Physical weathering is dominant, while the steep slopes and scanty vegetation permit rapid erosion; as a result the soils of the upland areas are thin, skeletal and immature. Most of the soil originally formed on the mountains and foothills is to be found as the parent material of the deep soils produced on the alluvial deposits of the valleys and outwash fans. The zonal soil, which occurs only on such deposits, appears to resemble the group of reddish desert soils[2]. The most important agricultural soils are those developed on the belt of fine alluvium between the stony outwash fans and the sand dunes in the centre of the basin.

The clay content, 15 to 20 per cent for the soils analysed, is sufficient to give the agricultural soils a soft or slightly hard blocky or massive structure when dry, becoming friable when wet, and allowing rapid infiltration and good aeration. Their water holding capacity is probably not high (moisture content at field capacity is 10 to 14 per cent of oven dry weight) but root penetration is deep, associated with a low bulk density. The soils are relatively easy to cultivate when moist except where they are very stony as in the foothills and mountain valleys. Except in local depressions no signs were seen that soluble salts had accumulated to an injurious extent on agricultural soils.

In the centre of the plain ruthless removal of all vegetation for fuel, even to the extent of grubbing up the roots, has left a large area of active sand

dunes encroaching to the south and east under the influence of the two dominant winds. Much cultivable land has already been lost in this way.

Analyses of cultivated soils showed that, as might be expected, the nitrogen level is very low in all soils (total 0·04 to 0·1 per cent) but rather higher on the cultivated than the uncultivated[3]. Available phosphorus (bicarbonate extract[4]) gave 12 to 50 ppm P in air dry soil which suggests that most crops would not show a phosphorus response. Exchangeable potassium is in moderate to good supply (0·4 to 0·8 m equiv./100 gm air dry soil), with adequate reserves of easily weatherable micaceous minerals. The soils are all calcareous, 10 to 25 per cent carbonate calculated as calcium carbonate, with a *p*H of 7·1 to 7·6, in M/100 calcium chloride solution.

Figure 2. Adit of an old qanàt, *abnormally tall due to the repeated lowering of the adit-floor: light from a ventilation shaft in the background*

Vegetation—The natural perennial vegetation of the plain is a sparse ' camel thorn ' association, with *Astragalus* and hardy xerophytic herbs, but nearly all but the least woody of the weeds for at least a day's journey round each settlement have been collected as fuel. Only in isolated valleys or on the high mountain tablelands is there a natural cover of perennial plants. At about 7–9000 ft the natural vegetation is an open scrub, succeeded by xerophytic mats and undershrubs at higher altitudes.

Qanàts—Sited according to the lie of the land and the local experience of a profesional *qanàt*-maker (*moghani*) the first or ' mother ' well of a *qanàt* is dug to tap a good aquifer, frequently beneath the apex of a gravel fan. From the base of the mother well a long adit (see *Figure 2*) is levelled by an

ingenious and accurate method involving two posts, a bucket of water and a knotted rope. This slopes slightly less than the land surface above, in order that the water flowing along the subterranean aqueduct is brought to the surface at the head of the fields to be irrigated[5]. Approximately every 150 ft there is a shaft to the surface for ventilation and the removal of spoil. Old *qanàts* are generally extended back into the aquifer, or enlarged by tributaries, to increase their flow.

Figure 3. Char Khanu; a mountain village (population 54) in the Kuh-i-Badaman range: houses are huddled closely together; sheep pens in the right and centre foreground; irregularly shaped fields are terraced where necessary

The figures for precipitation and transpiration emphasize the need of water for irrigation. Perennial streams and the Rud-i-Chari make a negligible contribution to requirements, and the use of reservoirs to conserve water, other than to save the overnight flow of a *qanàt*, is not common round Kerman. Even under the top of the gravel fans the water-table is generally as much as 30 ft deep. It very rapidly falls to several hundred feet below the cultivable soils. The wells are generally too deep for water to be raised directly, by draught animals or the cultivators, in quantities sufficient for irrigation. In East Persia the well known 120-day wind of Seistan provides the power by which traditional Persian windmills raise water from wells, but there is little summer wind in Kerman. The *qanàt* is therefore a more or less essential pre-requisite to settlement in Central Persia[6]. Although the majority of village *qanàts* are not more than three or five miles long, and 30 to 50 ft deep at the mother well, the size of the capital investment required to provide water for quite small villages is noteworthy. Capital costs of two *qanàts* studied[5] in 1950 were both approximately £30,000, with average annual maintenance costs of about £150. The *qanàts* yielded 2 and 1·3 cubic feet of water per second, to irrigate about 200 and 130 acres respectively.

People—The agricultural population of the Kerman area has two main components. First there is a Mohammedan majority, which in this area is a racially mixed group probably predominantly aboriginal Persian, with a strong admixture of Baluchi, and elements of Arab, Afghan, Turkoman and Central Asian blood. Secondly there is a Zoroastrian minority (Kerman is one of the two major Zoroastrian centres remaining in modern Persia) of Persians racially unmixed since at least the Sassanian period. Relations between the two groups are good. The only nomadic peoples associated with this area are small pastoral communities of mixed Baluchi, Turkish and Persian origins, and some wandering Luti or gypsy craftsmen, neither of which play a significant part in the agriculture of the area.

Figure 4. Jupar; a large village of the plain, showing houses and domestic gardens, walled gardens growing cereals (bare plot in centre), orchards (right foreground) and vineyards (vines trained on mud pillars to left of centre) 'satellites' and open fields beyond Jupar; Kerman at foot of dark crag in far distance beyond the desert

Villages—Within the area two distinctive types of village development may be observed. Typical mountain villages are found in groups in the high mountain basins of the Kuh-i-Badaman and the Kuh-i-Paiyeh, and singly in the foothills. These are small compact groups of houses sited near springs or perennial streams and housing some 30 to 100 people (see *Figure 3*). The houses are often half below ground and huddled together for shelter. Walled gardens are small or non-existent, and the area cultivated covers about 20 to 30 acres in the places where soil and relief allow. The crops produced are insufficient to support the population, and must be supplemented by grain and pulse from the plain. These are exchanged for the surplus produce of the considerable flocks, averaging 30 to 40 sheep or goats to each family; the income from carpets, whose manufacture occupies perhaps 1/10 of the working population; and the sale of firewood. Much of the land is owned by small landowners living in the villages.

The greater part of the agricultural population of the area, and the most highly developed agricultural production, is centred on the villages of the plain of which the cultivated lands lie on the alluvial soil round the edge of the plain. Such villages are mostly large with well-developed *qanàt* systems. Each is surrounded by a ring of small satellite villages, some of them barely more than walled gardens with resident caretakers. Jupar for example with a population of 4500 has five ' satellites ' within a mile and a half with populations of 330, 85, 20, 10 and 5, and is separated by some miles from the next large village (see *Figure 4*). The general pattern of a village on the plain is quite simple. The village itself, frequently surrounded

Figure 5. Ridged fields in a foothill village

by the remains of a defensive wall, is a sprawling tangled complex of single storied houses round small courts or domestic gardens, separated from neighbouring houses by narrow alley-ways or walled gardens. The village may be sited at the lower fringe of the gravel fan. Outside and below are the open fields, which are enclosed by small 12 to 18 in. ridges roughly along and perpendicular to the contour on gentle slopes (*see Figure* 5), and terraced on moderate to steep slopes. The inset to *Figure 1* shows Jupar and its five satellites. The area of the open fields is roughly equal to that of the walled gardens cultivated for crops.

A large village usually possesses more than one *qanàt*. Jupar and its five satellites have ten, which irrigate approximately 1500 to 1600 acres, to leave fallow in 1950 about 550 acres of the fields in regular cultivation. For the whole administrative unit (*baksh*) of Mahun itself and the sub-units centred on Langar, Qanat-i-Hassan and Jupar with a total population of 19,000, there are approximately 12,000 acres of irrigated land, and 37,000 acres of cultivated land at present (1950) fallow or derelict, and 300,000 acres of rough grazing.

Of the open fields cultivated in any year, probably 80 per cent are cropped for cereals or poppy, and the remainder for potatoes and melons, with occasional plots of fodder crops. The village flocks, averaging not more than two to three sheep or goats to each family, are grazed over the surviving vegetation of the alluvial fans, and the weeds and crop residues on the fields.

A large village in the plain normally contains a mosque, a school, and a bazaar (or at least an established market). Nearly all the trades ancillary to agriculture will be found in the village or bazaar. Up to $\frac{1}{6}$ or $\frac{1}{4}$ of the working population are carpet weavers. Generally the ancillary trades

Figure 6. Shepherd village in the foothills south east of Mahun: the channel (foreground) leads water from a small spring; the cultivated area is small, and about half is devoted to fodder crops

and the wealthier residents are concentrated in the major village, while the people of the 'satellites' are almost all cultivators. Approximate figures for Jupar and its satellites suggest that out of a total population of about 5000 some 1200 are carpet weavers and 3100 are cultivators and their dependants, leaving a balance of 700, mostly in Jupar itself, which includes all craftsmen, officials and other residents.

In addition to the two main types of settlement described, of which the villages of the plain produce surplus crops and a deficit of animal products, while in mountain villages the situation is reversed, there occur examples of every other possible variation. Small shepherd villages with a population of about 20 may be found in the foothills, or on the gravel fan, behind a village on the plain (*Figure 6*). They have negligible cultivable areas, and depend on payments in grain and pulse made to the shepherds by the owners of the flocks grazed round the villages. There are also small villages (with a population of 100 to 300) with a fairly even balance between

animal and crop production, watered by perennial streams or rudimentary *qanàts*, in the foothills, grazing large flocks and cultivating a moderate area.

INDUSTRIES

Ancillary trades—The main ancillary trades are those of the blacksmith, coppersmith, tinsmith, sheet metal worker, carpenter, potter and baker. There are also the miller, *moghani* and the water overseer appointed by the owner of a *qanàt*. The craftsmen are able to provide all the requirements of the village, though meeting increasing competition in the village from imported town made or even foreign made products. Corn mills are water driven, the head of water being obtained from a perennial stream on the sloping gravel fan, or by a sudden drop in the level of the adit of a *qanàt*. A horizontal wheel, driven by the water, is directly linked to the moving stone. Although most of the village corn is still ground in such mills, there is increasing competition from oil-powered mills in Kerman.

Carpet weaving—The only, and an extremely important, village industry independent of agriculture is carpet weaving for which most of the raw materials are provided from Kerman. Kerman carpets are made to a distinctive pattern and, until the trade was restricted, found a ready sale in Europe and the U.S.A. Most of the industry is controlled by large firms in the town, to whose agents in the villages the independent master weavers contract to manufacture carpets to a design produced by the firm, out of materials provided by the firm. Master weavers usually own two and occasionally four looms, and supplement family labour by engaging weavers to bring the numbers employed up to two or three to a loom. Jupar, with over 400 looms, engaging up to 1200 people, is fairly representative of a village of its size. In 1950 the industry was contracting as a result of a reduction in overseas demand, chiefly due to currency restrictions, purchase tax, *etc*, and the number of men unemployed was increasing. It is unlikely that the situation will have improved greatly.

LAND TENURE

Ownership of land round Kerman appears to be vested mainly in a limited number of families, of which the leading members may own many complete villages or groups of villages, and shares in a large number of others. More distant connections of the leading families, and others, may own only one or a few shares in a single village. As a result of sub-division on inheritance (equal full shares to sons and half shares to daughters) property is soon split up, and though recombination does take place by marriage and purchase, the holdings of all but the largest or the smallest landowners tend to be fragmented. The social prestige resulting from the ownership of land tends to prevent the sale of small holdings.

Ownership of the land and the source of its water is not necessarily the same, but in practice generally is so. The water from a *qanàt* is allowed to flow in turn, on a complicated 6 to 15 day sequence, depending on the crops and the water-holding capacity of the soil, on to the six equal parts (*dangs*) of the area of land regularly irrigated by it. The size of a *dang* and the number of *juft* or plough teams that each supports, depend on the volume of water produced by the *qanàt*. The share of one owner may be a whole number of *dangs* or even a fraction of a *dang*, but it is usual for the land of

one *dang* to be managed as one unit, possibly by one owner on behalf of all co-owners.

The owner of a share of the lands of a village may manage it in one of three ways. If the share is too small to support the cost of a bailiff, and too distant to be supervised, he may let it to a tenant or *mutajhir*, who is generally a small landowner or bailiff to an absent landowner, on a four-year lease for a fixed rent (in cash on the plain, sometimes in kind in the mountains). The *mutajhir* farms the rented land with the hired labour of landless peasants. If the share is in the village where the owner lives, or large enough to support the cost of a bailiff, it is more profitable for the owner to farm it with hired labour, or by share-cropping under his own supervision or that of a bailiff.

For cultivation as distinct from ownership the land of each *dang* to be cultivated under a share-cropping system is divided among the number of *juft* that its produce can support or that are required to till it. Each *juft* comprises three to five peasants under a leader, and a team of draught animals. One *juft* is usually the concern of one family, which may employ landless peasants to make up the team either permanently, or at seasons of greatest activity. There is no customary cooperation between *juft*; members have no legal security of tenure, but local tradition ensures that leadership of a *juft* normally remains in the same family.

Every year the lands to be cultivated in each holding, or *dang* of consolidated holdings, are divided into *juft* (areas) to be distributed by lot among *juft* (teams). Except on very small *dang*, supporting only a few *juft*, the teams therefore have little inducement to attempt to increase the fertility of the soil, by fallow cultivation before their year of tenure, or by other than minimal applications of manure. The landowner or bailiff orders which crops shall be grown. Walled gardens and orchards, unlike open fields, are almost invariably farmed by the owner, paying a gardner in cash or kind, or let to a *mutajhir*.

The division of the crop between landowner and *juft* varies from village to village. Hutk by Chatrud, just north of the area covered in *Figure 1* seems to be representative of villages on the plain. For a cereal crop, the landowner provides land, water and seed and pays taxes (about 10 per cent on yield) and in return is entitled to take 70 per cent of the grain, or 80 per cent of grain and all the straw if he provides the draught animals. In mountainous or stony areas, difficult to cultivate, the landowners' shares fall to 66 per cent and 76 per cent respectively, because of the greater amount of work required from the cultivators. For vegetables, maize, castor oil and lucerne, the landowner takes 75 per cent of the crop and also provides manure. The landowner takes 75 per cent of the crude opium if he provides manure and extra labour for harvest, otherwise only 50 per cent. The landowner often does, but need not, provide houses for the peasants farming his land.

Comparison of the crop-sharing system round Kerman with that elsewhere in Persia reveals that the cultivator's share is smaller round Kerman than almost anywhere else[7]. The disadvantages of such a crop-sharing system and the obstacles it raises against agricultural improvement are too well known to need comment. Indeed in dry-farming areas there would be little economic

justification for a landowner taking such a large share. However, round Kerman, where *qanàts* are essential and more highly developed than elsewhere in Persia, and the landowner must make a large investment for ensuring adequate water, the 75 to 80 per cent mulct on the yield of the land is probably justified. With several assumptions, rough calculations have been made of the probable annual net income to the landowners, and *qanàt*-owners, taking 75 per cent of the yields of the land irrigated by five *qanàts* in the Kerman region[5]. The average return on the capital costs of the *qanàts* is only 14 per cent. This return is by no means excessive considering the vulnerability of *qanàts* to malicious damage or earthquake.

PRICES

Prices of produce, quoted by the provincial Governor-General's office in Kerman, for the summer of 1950* were: potatoes 30 rials/50 lb.; wheat 91 r/50 lb.; barley 60 r/50 lb.; sorghum 38 r/50 lb.; vegetables average 70–100 r/50lb. Donkeys for draught cost 1–2000 rials; camels 3–5000; mules 5–9000; cows in milk 2500–3000 and dry 1–1500; goats and sheep, about 3–500 rials.

Peasant incomes—A prosperous *juft* will keep a share of its produce worth approximately 8–10,000 rials a year†. Wages of landless peasants are about 20–30 rials a day, or an equivalent payment in kind, but work is not always available. Carpet weavers are paid 20 rials for each 10,000 knots tied, earning about 15 rials a day as children and 30 rials as adults.

As it was estimated that the minimum cost of living was about 30 to 50 rials a day for a family, it can be seen that the combined family income, even when supplemented by casual earnings as servants, road-menders, collecting tragacanth, *etc* does not normally provide more than the barest subsistence‡ and provides no means of accumulating any reserves against ill health or a succession of bad harvests.

AGRICULTURE

Livestock—The role of sheep and goats in the economy of mountain and foothill villages has already been emphasized. In addition to meat, wool, skins and horn they provide *māst* (sour curds) and *roughan* (clarified butter). The communal herds under paid shepherds, ranging over the village lands and the surrounding country, often some distance from the village, are brought in and housed in low stone-walled pens every night. Women go out to the flocks during the day to do the milking. Landowners say that they are glad to have the benefit of the manure from flocks grazing over fallow or stubble, but in fact during the summer manure is very rapidly oxidized in the hot sun, so that the beneficial effect, if any, is likely to result from urine only. Landowners graze their flocks in the communal herd, or they may graze them by a form of share-cropping agreement with a shepherd, by which the greater part of all *roughan*, meat, milk, *māst* and wool produced is taken to the owner. In return the shepherd receives the remainder of the produce of the flock, an annual present of clothing, a small cash sum, and an annual payment, in kind, of agreed weights of barley and

* 170 rials = £1.
† Figure provided by the Governor-General's office, Kerman.
‡ See reference 7 p. 368.

wheat for each animal in the flock. There are leopards, wolves and bears in the mountains, which cause considerable losses.

Because of the great heat and absence of shade trees cattle are kept under cover during most of the summer so that it is difficult to estimate their numbers or importance. Their function as draught animals is probably as important as the provision of meat and milk products. Most of the cattle are kept in byres in the village during the winter, and fed on hay from irrigated grass or lucerne crops and the dried weeds gathered from the fallow fields and unenclosed land. However, there was evidence that some at least were moved to *garmsir* (' cold harbour ') in the Jiruft area, 40 to 50 miles to the south east, during the winter, and it is certain that cattle from some mountain villages were wintered on the plain. In either case the cattle are grazed on the plain and hillsides in the spring to benefit from the flush of annual plants at the beginning of the warm season.

Donkeys, mules, horses and (less commonly in this area) camels, are kept. Donkeys and cattle generally provide most of the draught for ploughing: donkeys and camels are the main pack animals, and horses or mules are used normally for riding. Partly because of the lack of good minor roads, and partly because of the scarcity of timber, also the cause of the domed mud brick roofs, few carts were seen. Minor transport of goods and grain is still provided mainly by donkeys. Bulk transport of grain and coal, and passenger transport between the villages and Kerman is being taken over by lorries and buses, which are also displacing camels from the main caravan routes between towns. Mules and horses receive barley and fodder all the year. Camels are grazed on the sparse growth on the plain during the summer, and wintered outside the area. Donkeys receive hay during the winter, and generally enjoy only rough grazing during the summer.

Poultry are common in all villages and, in the absence of small game, probably make an important contribution to the diet of peasant households. The eggs and fowls are small.

Crops—A wide range of temperate and tropical crops are grown, of which wheat, poppy, barley, sorghum, potatoes and melons are probably the most important. Potatoes, melons and some vegetables are grown on ridged plots, and the remainder in basin fields or terraces. Crops are described locally as *shatvi* (winter) or *sayfi* (summer), depending upon when they are sown, but the same crop may be grown as *sayfi* or *shatvi*.

Shatvi crops are sown in autumn and harvested in the following spring or early summer. As many as possible of the *sayfi* crops are grown to ripen before or reach their period of maximum growth after the period of maximum transpiration and water requirement and may be divided into three groups: (*1*) spring crops: sown and harvested before mid-summer; (*2*) summer crops: sown in spring or early summer and harvested in autumn (mainly fruit and vegetables); (*3*) autumn crops: sown after mid-summer and harvested in autumn or early winter.

Wheat—This is grown mainly as a *shatvi* crop except in exposed sites. When the autumn and winter are unusually cold, sowings may continue until mid-February, and therefore are harvested in July to early August. Seed is broadcast at a rate of 100 to 150 lb./acre on a moist seedbed, generally manured, in November or late October. If necessary the crop is irrigated

twice before the winter rains, starting about three to four weeks after sowing, and again after the end of the spring rains. The acreage sown is such that during the period of maximum growth the supply of irrigation water is insufficient to fulfil all the demands of the crop. In a good year the water requirement in excess of the water supply is adequately met by the winter and spring rains, of which part is conserved in the subsoil. Failure of all or part of the rains is critical. In the spring irrigation takes place every 6 to 12 days depending on the texture of the soil (stony soils are recognized to have a lower moisture holding capacity and therefore to require more frequent irrigation) and the customary division of the water. Winter wheat is harvested in early July. The yield is said to be about 20- to 30-fold round Kerman, and up to 60-fold in the *garmsir*, but in the only instance where weights of seed and harvest were compared, the yield was about 6- to 7-fold, and yields of up to 10-fold or about 700 to 1000 lb. grain/acre appear to be more representative.

Poppy—The opium poppy produces a product of high value for small bulk, and has a lower water requirement than most crops. It is therefore a very suitable cash-crop in an arid area with poor communications, and is widely grown even in the isolated valleys of the mountains and foothills. Opium-addiction is widespread. In November to December the seed is broadcast on a carefully cultivated and manured seedbed. The seedlings are thinned out to 12 in. spacing, or transplanted, during January to February, and the fields are regularly weeded until harvest. A further application of farmyard manure is made during January to April. Irrigation begins during March or April, depending upon the spring rains, and continues until harvest at intervals of about 15 days, possibly requiring only two or three applications. The opium is harvested during June and July just before the petals fall. Three small gashes are made on each pod during the afternoon, and the congealed latex collected the following morning. The admitted yield is about 1·5 to 2 lb./acre of crude opium, which is very much less than the commonly accepted figure of ' 20 lb. opium/acre ' for the tropics[8]. Poppy seed is harvested in the ripe pods in late July, and crushed for edible oil. Opinions differ[9–11] on whether the net result of crop and manure is to impoverish the soil or not; on the whole landowners in the area acted on the assumption that a manured crop of poppy leaves some residual benefit for the following crop. A *sayfi* poppy, with a three months growing period, has been reported[11], but was not encountered in 1950. It is said to produce opium of lower quality than the *shatvi* crop.

Barley—The crop is sub-divided locally into sweet (*Jou-i-shirin*) and sour (*Jou-i-tursh*) barleys. *Jou-i-shirin* as a spring crop is sown early in February and harvested early in June. As a *shatvi* crop it is sown from November onwards, but this appeared to be less common. The seedbed is generally manured, but less consistently so than wheat. Germination takes approximately 15 days, and the crop is irrigated every 20 to 25 days (perhaps two or three times in all) when rainfall is not adequate. The rate of seeding was said to be about 30 lb./acre, but this rate seems very low and is probably inaccurate. The yield varies widely, but an average yield is probably about 700 to 1000 lb./acre.

Jou-i-tursh, the autumn barley, is sown during the first half of August,

normally following a manured *shatvi* crop, and harvested at the end of October.

Sorghum—Cultivated as feed for poultry and livestock, and as a diluent of bread grains, it is normally grown as an autumn crop, following the harvest of poppy or a *shatvi* cereal, and in principle precedes a fallow year. Sorghum is sown in early August and harvested in early November. Irrigation starts 24 days after sowing and continues every 10 to 12 days (about three or four times in all). This crop does not appear to be grown in the mountains, where its place is taken by maize, possibly because of the earlier onset of frost.

Maize—This was not seen growing as a main crop on the plain and is not a major crop in the area, though occasional plants were grown on the ridges of potato and melon fields, to be harvested in the autumn. It was reported that maize was sometimes grown as a late autumn crop, sown in September and harvested in December. In some mountain villages maize is cultivated as a main autumn crop, following *shatvi* wheat.

Potatoes—These are grown as a *sayfi* crop, being set and ridged in May after an application of manure and a green mulch of perennial weeds gathered from the fallow fields. The crop is lifted in early September and is expected to yield about 4 to 5 tons/acre in a good year. The crop is said to have lower water requirements than melon. *Striga* in flower was conspicuous in the potato fields.

Melon—There are several varieties (*hendevone* and *karbiza* are local names of the most important), which form the main vegetable crop in the villages and market gardens round Kerman, grown as summer and autumn crops, for pulp and seeds. The crop is sown on manured plots from early spring onwards and subsequently manured and ridged. Irrigation takes place approximately every seven days, which is more frequent than for cereals. Two varieties were already ripe in mid-July and others continue to be harvested until early autumn.

Oil seeds—Grown locally, called *Gal* and *Gav-(khaneh)*, as summer and autumn crops on a few plots only and these were not identified.

Pulse—Species of *dal* (Cajanus) (locally *māsh*), *lubia* (Dolichos) and an unidentified Gram pea (*nakhod*) were grown as summer crops, sown from February onwards and harvested during August to December. All are said to benefit the following crop, but they nowhere occupy large areas, nor apparently a regular place in the rotation.

Linseed is cultivated only for the seed, and is harvested in mid-August. Castor is grown as an annual *sayfi* crop. Sunflower, grown as a summer or autumn crop for seed and presumably fodder, is scattered along the ridges of potato and melon fields, and the retaining banks of basin crops. Sugar-cane was only observed on an experimental plot. Lucerne is the most important fodder crop. Its habit is different from that of the lucerne grown in England, but unfortunately the specimen collected was lost on the overland return to Oxford, so the identification could not be confirmed.

Vegetables—Carrot, beet, turnip and possibly *Brassica* spp. are grown as *shatvi* or *sayfi* crops. Onion, tomato, aubergine, chili, carraway and pot-herbs are grown as spring and autumn crops. *Sayfi* vegetables are irrigated every 7 to 10 days and since they grow throughout the hot season have a

very much greater total water requirement than cereals. For example approximate figures for total annual water consumption are: wheat and barley 75 in.; orchards 100 to 110 in.; vegetables 120 to 130 in., which also show that irrigation exceeds transpiration by a factor of two to four, of which surplus perhaps 25 to 30 in. would be sufficient to leach the soil of accumulated soluble salts.

Fruits—Include apples, ripening in late July; apricots; cherries, ripe mid-July; figs; grapes—many varieties, trained on mud pillars in the absence of wood and ripe from July to September and probably later; mulberries, ripe in mid-July; pears; pistachio nuts, an important export from the area, and favoured by saline soils; pomegranates, ripening in mid-August; sorb-nuts and walnuts.

Rice; madder, formerly grown at Isfahan and Yezd[12]; saffron, formerly grown in the Kainat area of East Persia[13]; henna, grown near Bam to the south; and dates, grown at Yezd and Bam were not seen or are known not to grow in the Kerman basin. Tobacco and cotton were not observed in the area, but may be cultivated in some villages.

CULTIVATION AND HARVEST

Some days before cultivation the soil is made friable by irrigation. In small plots and gardens the soil is turned over by spade, but the usual implement is the traditional iron-shod nail-plough, which leaves an open, coarse cloddy tilth. Manure collected in the byres, sometimes mixed with soil and dried, and night soil, is applied before ploughing or when sowing. The prepared seedbed may be left for some days before sowing, or ploughed and sown the same day. In contrast to the practice in some Tehran villages[14] where fields are ploughed after seed has been broadcast on the unprepared surface, seed is broadcast on the moist prepared seedbed and loosely covered. Poppy, and, less consistently, winter cereals are weeded during the winter, and vegetables are carefully weeded during the summer, but the remaining *sayfi* crops often have to remain unweeded during the harvesting of earlier crops.

Cereals are reaped by sickle. The grain and straw are gathered together and carried in loose bundles to temporary threshing floors, where the bundles are piled into large round heaps about 3 ft high and not less than 6 ft wide. Round Kerman the threshing sledge (*Figure 7*) takes the form of two wooden rollers, 4 to 5 ft long, studded with iron blades, 2 in. wide and $\frac{1}{8}$ in. thick, extending about 3 to 4 in. from the wood, and mounted below a massive wooden frame. The frame is heavily weighted and drawn along the outside edge of the heap of corn by a yoke of cattle. As the ears are broken straw is removed to the outside of the circle and more unthreshed grain is pulled outwards from the centre. Round the circle stand a ring of peasants, with forks, who turn the corn to allow the threshed grain to sink and bring straw to the top. The grain is winnowed in the mountain winds of the late afternoon, sieved, and carried to the village in coarse, closely woven bags of goat or camel hair, slung in pairs across donkeys or horses. Straw and chaff are stored for fodder and litter.

Rotation of crops—Since *qanàts* usually come to the surface above a village, the walled gardens have first call on the available water. They are therefore

manured regularly and cultivated every year, without any observable regularity in the succession of crops or vegetables. For the open fields on the other hand, there is, in principle, a regular two year rotation of crops in the Kerman area (*cf.* reference 15):

first year; fallow till autumn; sown to manured *shatvi* crop,

second year; *shatvi* crop harvested in spring or summer; *sayfi* crop sown and harvested; land left fallow during winter and following summer.

Figure 7. Threshing sledge

This is modified occasionally by the introduction of a year with one or two *sayfi* crops, spring and autumn. It is generally agreed that pulses increase the productivity of the soil for the following crops, and that manure given to one crop produces some response in the succeeding crop, particularly if the first (manured) crop is *sayfi* and irrigated during the hot season, *e.g.* melons and potatoes. So pulses and manured crops are almost always followed immediately by another crop. There is no agreement as to the effect of lucerne (and the manure it receives) on the following crop. One landowner for example claimed that lucerne may be grown for five to six years continuously with frequent irrigation and annual applications of manure, and the land is greatly improved. Another said that during a six to seven year crop of lucerne the land deteriorated continuously, and that lucerne must be followed by a well-manured crop of melons to restore soil productivity. It is more likely that the adverse effect of lucerne on its successor is due to a temporary reduction in available potassium than to the drying-out of the subsoil, in view of its very frequent irrigation (*cf.* however, reference 16 which comments on the high potassium and phosphorus requirements of lucerne grown on Kansas soils.)

In general the fields left fallow between crops are given no treatment or cultivation: ' if there is water the field grows a crop, if not then it is left alone ', was a fairly common reply to questions, and it seems that fallow is considered as a period of ' rest ' for the field, more than anything else. In one village some attempt was made to conserve water by diverting winter floods onto fallow fields, and in another, one landowner customarily ploughed his winter fallows two or three times during the winter, and claimed that this cultivation benefited the following crop, possibly by reducing run off and conserving water.

Table 2. Rotation of crops in the Kerman area

Site, Field and Condition	1947	1948	1949	1950	1951
Char Khanu					
1	W — W	W — —	M M M	— — W	W
2 *Good soil; near water supply*	— — W	W — —	M M M	P P W	W
3	W — S	— — —	M M M	T T —	—
15	— — W	W — O	O — O	O — W	W
16 *Badly sited in regard to water*	— — —	— — —	— — —	— — W	W
19 *supply*	W — —	— — —	— — —	— — W	W
Sagurch					
8 *Stony soil; near water supply*	— — O	O B W	W — O	O — B	—
4 *Stony soil; more distant from water supply*	— B O	O — —	— — —	— — —	—
Jupar					
2a *Fields at northern edge of culti-*	— — —	— — —	— — W	W —	
2b *vated land and therefore most*	— — —	— — W	W — —	— — —	
1a *distant from water supply*	— — W	W — —	— — —	— — —	
5b *Fields less distant from water*	— — O	O — O	O — W	W — —	
6e *supply*	— — —	P P —	N N W	W — S	
6f	— — —	N N —	P P W	W — —	
10a *Fields near southern edge of*	— — O	O S O	O — S	P P —	
10b *cultivated land; near to*	— — —	B B O	O — S	P P —	
10c *water supply*					
10f	— — —	Mn Mn —	B B O	O — S	

The three symbols for each year represent the crops on the ground during most of the spring, summer and autumn respectively: W wheat; M maize; P potatoes; S sorghum; T turnip; O poppy; B barley; N *Nakhod*; Mn melon; — No crop.

However, the simple rotation described is normally modified and obscured by other considerations. First, the crops most sought after by the night-raiding antelope, wild goat and porcupine, mainly vegetables and fodder crops, must be grown near to the village, where they can be most easily guarded. Secondly to avoid heavy water losses, estimated at 20 to 30 per cent of total consumption, in the channels distributing water between the fields, those nearest to a *qanàt* mouth tend to be cultivated every year, and those at the lowest end of the cultivated lands may be cultivated only in years of exceptional rainfall. Finally the water requirements of the different crops are not the same, so that for a constant flow of water the area that may be irrigated and kept in the rotation varies through the year, and all or part of fields may become and remain out of step. For the stranger the picture is

confused still further by the readiness of cultivators to grow small areas of melons or quick-growing vegetables wherever canalization of the run-off of the spring rains has left small patches of soil sufficiently wet to raise a crop with little need of further irrigation. *Table 2* emphasizes the extent to which the simple rotation described is modified by practical considerations.

Soil nitrogen—It is probable that the relatively low yields are mainly due to the low level of soil nitrogen. For example yield increases of about three tons on 10 tons/acre of potatoes (for nitrogen applications of 40 to 80 lb./acre), and of 40 bushels on 40 bushels/acre of maize (for applications of 40 to 80 lb. of nitrogen per acre) have been obtained on similar soils (organic matter less than 1 per cent, total nitrogen 0·03 to 0·05 per cent, and rainfall 6–10 in.) in the Columbia basin of the United States[17]. Also row crops on alluvial soils round Isfahan in Persia[18] are said to show up to 50 per cent increases in yield after the application of pigeon guano (6 per cent nitrogen, 2·7 per cent phosphate, 0·8 per cent potash) at a rate of 1·2 metric tons per hectare.

At present rates of irrigation it is unlikely that lack of soil moisture would limit the response of crops to an increase in available nitrogen*, and the main obstacle to increased production is the lack of an adequate local supply of nitrogenous fertilizers. The manure and night-soil collected conserve part of the soil nitrogen and keep it in circulation, but since most of the village diet and fodder are obtained in the first place from the fields to be treated, the use of farmyard manure cannot raise the nitrogen level of the soil. There are no ' pigeon-towers '[18] in the Kerman area to provide guano. Some landowners are reported† to be using a ' waste product ' from the fish-canning factory at Bandar Abbas to fertilize pistachio orchards. If the increased value of the crop can repay the considerable transport costs of a relatively bulky waste product, the import of concentrated inorganic nitrogen fertilizers through Bandar Abbas or Bushire might prove to be an economic proposition.

' Sind or monsoon fallows '[20] to increase the available nitrogen, presumably by increasing the rate of mineralization of organic nitrogen, are not possible in the absence of summer rainfall, but it should be possible to spare some water during the summer from *sayfi* crops, whose irrigation considerably exceeds minimum requirements (*cf.* figures on page 23). Monthly irrigation during the early summer (to wet the top 9 in. only) of fallow fields due to be sown in the late summer and autumn would probably increase the soil nitrate content sufficiently to cause a marked response by the following crop. The fairly marked increase in the total nitrogen level of cultivated (0·04 to 0·1 per cent) over uncultivated (0·02 per cent) soils has also been observed during experiments on the similar Mohave and Gila soils in Arizona[3]. The increase is rather greater than might be expected as a result of the moderate applications of farmyard manure, suggesting that significant non-symbiotic nitrogen fixation may occur in the irrigated soils, in spite of their very low C/N ratios. It might therefore prove to be profitable to plough in during the summer a green mulch of the tough perennial plants growing as weeds on all land not under a crop, to act as a carbon substrate for non-symbiotic nitrogen-fixing organisms.

* Cf. reference 19.
† See reference 7 p. 362.

GENERAL

The Persian peasant shows himself (within the limits of his social environment) to be a skilful and ingenious cultivator by any standards, making the most of the limited natural advantages of his harsh physical environment to provide a meagre living. Although the cultivation of small scattered plots with a maximum amount of labour and minimum use of machines may not be the most economic way of producing a crop, it has at least the merit that it employs and therefore feeds a large number of people, for whom there is no alternative employment. Now that improved roads and motor transport have made it possible to export grain in bulk from the area, it would probably be to the financial advantage of at least the larger landowners to consolidate and mechanize their holdings as far as possible and produce the same yields with a very much smaller labour force.

Mechanization would of course only be profitable if the necessary services for supplying spare parts and carrying out repairs were developed simultaneously. In the long term view the political disadvantages of creating a large pool of unemployed by this means (already quite serious round Kerman) greatly outweigh the financial advantages. It is greatly to be hoped therefore that the most important landowning families (among which many of those in Kerman already take an enlightened view of their responsibilities), will continue to take a long term view and increase yields either within the present system by small-scale mechanization and the extension of irrigated lands by constructing new *qanàts* or sources of water, or by large scale mechanization coupled with an increase in the area irrigated, at least large enough to provide work for cultivators disemployed by mechanization. Water-pumps driven by oil-engines are an obvious form of mechanization, with which some landowners are already experimenting. There are, however, several practical difficulties, among which are the problems of servicing and spares mentioned above, which will probably limit the use of pumps to areas near to towns or large villages with particularly high-yielding aquifers.

Qanàts have the advantage that they are able to draw upon very poor aquifers, and the use of simple machinery by the *moghanis* would probably reduce their cost. Within the present system there might be an immediate increase in yield if the lands of each *dang* were shared permanently between *juft* so that the peasants might have a more personal interest in increasing the yield of their plots by summer irrigation and conservation of water.

ACKNOWLEDGEMENTS

Many facilities were provided for the Oxford University expedition by H.E. the Governor of Kerman province, to whom grateful acknowledgement is made. Two papers were specially written for the expedition by the staff of the Governor-General's office, and local information on crops and land tenure was provided by numerous landowners and cultivators in Neckar Ku, Hutk, Jupar, Mahun, Sagurch and Char Khanu villages. To all these, and to Mr Ahmed Saam of Tehran, who translated the enquiries made by members of the expedition, the members of the expedition wish to express their appreciation and thanks.

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I am indebted to Dr A. D. H. Bivar of the Ashmolean Museum, Oxford, for providing the following information gained during a recent journey in western Persia. Dates in October and November refer to operations actually seen by Dr Bivar. Dates in the spring and summer are from information provided by cultivators and should be accepted with caution. Abadeh (between Isfahan and Persepolis): *shatvi* wheat being sown 19 October to be harvested 19 June. Naqsh-i-Rustam (near Persepolis): *shatvi* wheat, cucumber, melon, *hendevone* being sown 20 October. Rice being harvested. Shiraz: Cotton being cleared and resown on 22 October. Qasr-i-Shirin by Kermanshah: *shatvi* wheat, barley, peas and pulses being sown on 1 November. *Sayfi* wheat, barley and cotton to be sown 1 April. Bisotoun by Kermanshah: *shatvi* wheat and barley being sown 2 November, to be harvested 2 July (yield 10: 1). *Sayfi* cereals being threshed on 2 November. Pass between Hamadan and Qasvin: *shatvi* wheat to be sown on 5 November (yield 12 or 15: 1).

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The Wageningen Rice Scheme in Suriname

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In most atlases one would look in vain to find Wageningen marked in Suriname. Six years ago it was not yet in existence. On 24 September 1949, a small group of men ascended the Nickerie river in north west Suriname in an outboard motor-boat. They went ashore at the place which is now known as Old Wageningen; they cut a way through the thick undergrowth of the tropical forest with difficulty. A clearing was made and embanked, with a small drainage channel to the river; a few huts were built. A beginning had been made with the implementation of the Wageningen plan.

In 1950, the final position of Wageningen village was established opposite a tributary river, the Maratakka. The camp was moved to this site and shortly afterwards the arrival of more workers transformed it into a small village. The first draglines and bulldozers arrived in the middle of 1951. At this period, ground reconnaisances had to be made through standing water, while progress through the swampy bush was so difficult that a distance, which can now be traversed by car in a quarter of an hour, then took an expedition 14 days of hardship.

ORIGIN OF THE FOUNDATION FOR MECHANIZED AGRICULTURE

In the years immediately after the 1939–45 war, various public and private bodies in the Netherlands and Suriname turned their attention to the possibilities of mechanized agriculture in the wide, fertile and largely uninhabited coastal plain of Suriname. An expert commission under the leadership of Professor W. F. EYSVOOGEL was appointed by the government in 1948, and made a favourable report. The governments of Suriname and of the Netherlands, which accepted the findings of the commission, entrusted the execution of the plans to the Foundation for the Development of Mechanised Agriculture in Suriname which was established for this purpose in August 1949. The board of management, the controlling body of this foundation, consists of five members, of whom two are appointed by Suriname, two by the Netherlands, and one—the chairman—in joint consultation.

The foundation is entrusted with all planning and execution of works regularly undertaken to develop the projected polders, or those which may be projected in the future. It has authority over the administration of the polders as far as the tenancies of the farmers are concerned and the repayment of advances made; there its powers end. The task of the foundation, a non-profit-making body, is one of service; because it works for the most part with borrowed capital, on which interest must be paid, it is organized on a strictly commercial basis.

In 1950, agreement was reached on the development on a first polder of 5000 hectares. The whole concession is 50,000 hectares in extent, and a staged plan was prepared so that the initial scheme for 5000 hectares is planned as part of future developments to a minimum of 15,000 hectares. In the first plan, provision was made for the establishment of a village on the river with pumping machinery for irrigation and drainage of the polder, and with silos, mill, and drying plant for handling the rice crop. This plan also covered the procurement of the necessary agricultural machinery for the area to be brought under cultivation.

AIMS AND OBJECTS OF THE WAGENINGEN PLAN

The most important aim of the plan is to strengthen the economy of Suriname by providing an example of the development of a prosperous intensive agriculture. At present, the prosperity of Suriname depends upon a single product, bauxite; and this is on a very restricted basis. The Wageningen plan envisages the establishment of a great number of modern, mechanized, middle class professional farmers with rice as their main crop. The creation of this class depends upon the attraction and careful selection of young Dutch farmers.

In Holland, there is a great shortage of land. Very many farmers' sons cannot nowadays obtain holdings; by emigrating to Suriname, they will retain strong links with Holland, in contrast to emigration to Canada and Australia. There is also opportunity for Suriname farmers to join the enterprise, provided that they fulfil the same requirements of professional competence. In addition Suriname is bound to profit from the experience gained. The application of modern agricultural methods is a valuable demonstration for the Suriname farmers, who can visit the scheme, and it is a good educational opportunity for the hundreds of drivers, mechanics and labourers employed, many of whom will, as soon as they have earned a certain amount of money, start a farming enterprise. In all its undertakings the Wageningen project strives for efficiency, that is to say the production on an economic basis of a product of good quality.

SOIL, CLIMATE AND VEGETATION

Pedologically, Suriname can be divided into three regions:

(i) the young coastal plain which consists of a zone 30 to 50 km wide with level expanses of clay soil, interspersed in places with belts of sand;

(ii) the old coastal plain; this gently undulating country begins behind the young coastal plain, and consists principally of sedimentary sands ;

(iii) the hilly country further inland.

At present only the young coastal plain is of agricultural importance. Most of the population live in this area, and the Wageningen scheme is also situated in it. Before development began, two-thirds of the site of the present polder was covered with swamp bush and the rest with tall grasses and reeds. Except in periods of extreme drought, the whole area was under water.

The climate of the Suriname coastal plain belongs to the tropical rain belt. The average annual rainfall for the Nickerie district is about 2000 mm. Nearly half of this falls in the main rainy season, during the months of May,

June and July. The main dry season is in September, October and November, and this is followed by the small rains (December and January) and a small dry season (February and March). These indications are based on average figures. The rainfall is in general very irregular; only the main wet and dry seasons recur with any regularity every year. Temperatures are, for a tropical country, very moderate; the nights are cool, and by day a light breeze generally blows off the sea. Storms and hurricanes are very rare in Suriname and their absence considerably reduces the risks of farming.

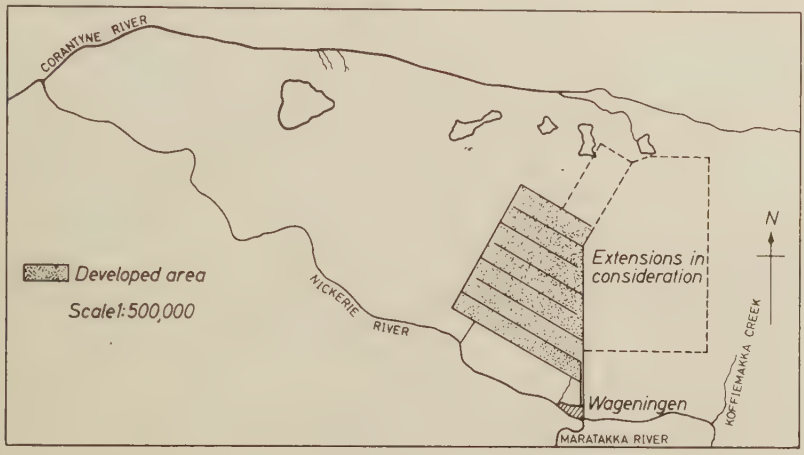

Figure 1

Rice is the crop which offers the best prospect in the circumstances of soil, climate and labour of the Wageningen scheme. Of the annual crops, soya beans, sorghum, maize and groundnuts have been tested, but the risks with them are too great when the susceptibility of these crops to excess of water is considered. Perennial crops, such as cocoa, coffee, and oil palms are less suitable because of their high labour requirements. Moreover, a combination of rice with tree crops is not attractive. After rice, cattle raising offers the most favourable prospects at present.

LAY-OUT

Situation of village and central services—In consequence of the low flat nature of the area, arrangements for drainage had to be undertaken. Moreover, most of the irrigation water has to be provided by intake from the Nickerie river. Pumping machinery was designed which develops 1200 horse-power and can serve both for irrigation and drainage. The position of this pump was fixed by the limit of salt water in the Nickerie river, and this can safely be put at the junction with the Maratakka tributary. The mouth of the Maratakka makes a convenient turning-point for sea-going ships, so that a preferred site offered itself for the rice mill, the silos, the warehouses and the jetties. The same motives decided that the public utilities should be established in an adjacent position.

Situation of estates, canals and ditches—The first area to be developed is of 5600 hectares. A strip about 5 km wide along the river was excluded from this, because of the heavy bush which would make clearing costly, and

because of the unevenness of the ground caused by old river banks. The lay-out of the rest of the polder is shown in *Figures 1* and *2*.

The main irrigation canal, which serves the whole, has a sluice for each 144 hectares. From each of these sluices a secondary irrigation channel branches off, and waters 12 fields, of approximately 12 hectares each, by two shuttable pipes per field. The fields are approximately 600 metres long and 200 metres wide. The separation of the fields has been effected by bunds of two or three cubic metres, for which the soil comes from the adjacent field ditches. The water is led through the fields by these field ditches, and drainage is also through the same ditches. Similarly, there lies on the other side of the field a secondary drainage channel, with two shuttable exit pipes to each field. The secondary drainage channels are in open connection with the main drainage canal.

Farm units—The farm buildings are situated on the main irrigation canal opposite to the secondary drainage channel. The lay-out described ensures units which are all of 6 × 12 hectares. The allotment of tenancy rights is by preference in units which are multiples of 72 hectares (1, 2 or 3 × 72 *etc*).

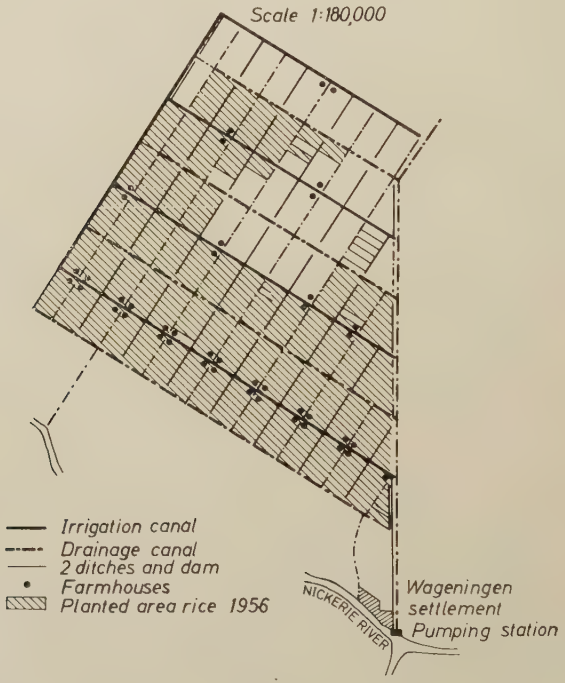

Figure 2

Originally one dwelling-house with an implement shed and driver's house was built on each unit of 72 hectares—29 units, in the first and second series. From the concurrent experiment of the rice culture economy, it appeared that units of this size were too small to provide an adequate financial surplus, or sufficient work. On the remainder of the polder, dwelling-houses were provisionally built only at the rate of 1 to 250 hectares, while the number

Figure 3. Excavation of canal

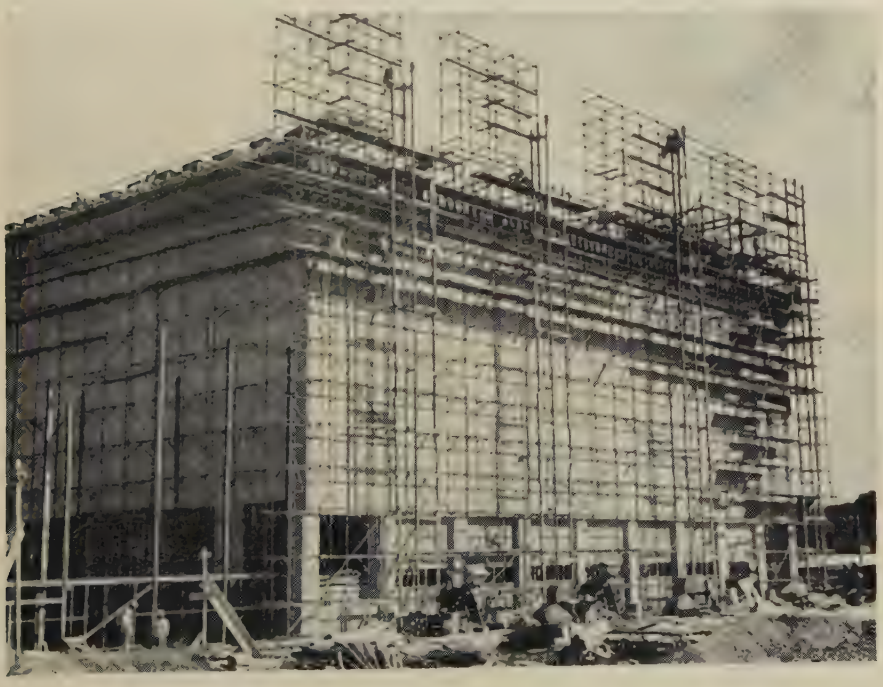

Figure 4. Construction of silo

of sheds and of drivers' houses was kept constant. All the farms are connected to the electricity supply.

Transport—It was originally intended to construct a network of roads with a gravel surface, but because of the high cost of serviceable roads over these distances in construction and maintenance, this has been provisionally abandoned. All transport is carried out by boats on the irrigation canals. In the dry seasons the small causeways are quite practicable for jeeps. The plan envisages the evacuation of rice, harvested by combines, by lighters to great central driers and silos in the village on the river.

Figure 5. The first farm house

Storage and processing of rice—The concrete silo has a usable content of 25,000 cubic metres, and is constructed for vertical working with mechanical delivery and removal. Beside it a modern rice mill has been built, capable of producing various qualities of rice.

PROGRESS OF THE WORKS

The lay-out of the village, the installations for storage and processing of rice, and the pumping station are complete. The farm buildings and the irrigation and drainage systems and their ancillary works will be completed in August 1956 for the first project of 5600 hectares. Two-thirds of the polder area had a cover of swamp bush. In the south this bush consisted principally of *Erythrina* sp., sometimes mixed with *Triplaris* sp.; further to the north this was succeeded by a more shrubby vegetation with *Tabebuia* sp. and *Pterocarpus* sp.

Almost all these woody plants were ringed and poisoned with sodium arsenite. One to two years later the bush was levelled with chains between bulldozers, or directly by heavy tractors which pulled brushcutters behind them. This was followed by a burn in dry weather, after which the remains of the timber were gathered in heaps. It was possible to follow this directly by cultivation for the first sowing.

One third of the polder had a grassy covering, consisting of a vegetation complex including *Cyperus giganteus*, *Typha* sp., *Cyperus articulatus*, *Scleria* sp., ferns *etc.* As soon as it had dried off, the vegetation on this land could be cut with brushcutters and burned, after which ploughing followed. A large part of this area was also ploughed directly, without previous treatment.

Figure 6. Canteen for labourers

The following areas of rice were sown and harvested in each of the half-yearly seasons shown: 1953–4 20 ha.; 1954 450 ha.; 1954–5 515 ha.; 1955 1942 ha.; 1955–6 270 ha.; 1956 *c.* 4000 ha. sown. The double-year figures refer to the second sowing, which takes place after the main crop is harvested.

ORGANIZATION AND METHODS OF RICE CULTURE

All personnel concerned with rice production, including the farmers, are directly employed by the Foundation. The lease of the farms will only be considered when the project is completed, and the total costs of development are known. Owing to the demands which commercial mechanized agriculture makes in a remote area, those farmers who in the future become definitely established must remain subject to stringent regulation.

The Agricultural Service, which has the following sub-sections: management service; field repair department; an experimental farm; and a seed supply organization, prescribes the methods of cultivation for the farmers, but in the details of execution wide freedom is allowed, so long as methods are consonant with efficient production. A system of premiums provides extra rewards for good performance.

The total area under cultivation, which now in 1956 has reached about

Figure 7. Ploughing of new land

Figure 8. Rexoro rice infected by Piricularia *disease*

4000 hectares, is divided between the following forms of land use: experimental area 100 ha.; seed production 180 ha.; eight productive units of 144 ha., 1152 ha.; three productive units of 288 ha., 864 ha.; four units of 300 to 500 ha. under development 1600 ha. Each of the units named is separately administered.

Rice cultivation at Wageningen is intensively mechanized. At present there is on the average one Dutch professional farmer to 200 ha. (thus making a total of 20), while drivers and their assistants amount to about one man per 35 ha., and mechanics and assistants to about one man per 200 ha. Unless use is to be made of aeroplanes, seasonal workers must be taken on at the main sowing season for sowing by hand, at the rate of about one additional man per 80 ha.

The machinery park comprises at present the following cultivation equipment: 51 45 h.p. caterpillar tractors, 31 12 ft combines, a few wheeled tractors, and diverse types of ploughs, disc harrows, trailers, pest control apparatus *etc.* There are on order 12 more 14 ft combines, 12 45 h.p. caterpillar tractors, and 7 50 h.p. wheeled tractors.

Figure 9. Combine harvester at work

The preparatory cultivation which is undertaken depends on the circumstances. In years of continuous rain (1954 and 1955) only puddling is done. In a dry year (1956) ploughing and one to two disc harrowings are carried out, followed by two rollings and fitting with water on the land. Sowing is done with pre-germinated seed, usually broadcast by hand, after which, either immediately or with an interval of up to three weeks, water is applied to a depth of 10 to 20 cm. The main sowing season is in April to May, and the harvest in September to October; the second crop is sown in October to November and harvested in March to April. Through the agricultural experiment station of the Suriname government and the selection work of the foundation several new varieties of rice have been developed, which are

better suited to the conditions and method of cultivation than the indigenous varieties.

The control of weeds with *MCPA* or mixtures of 2,4-D and 2,4,5-T has found a very necessary place. The government of Suriname has at its disposal two helicopters, one of which at least is usually available for spraying. In 1955 some 1800 ha. were sprayed with favourable results. The principal weeds are: *Cyperus giganteus*, *C. articulatus*, *Fimbristylis miliacea*, *Jussieua* sp., *Aeschynomene* sp., *Sesbania* sp., *Sphaenoclea zeylanica*, *Typha* sp., and the grasses *Panicum* sp., *Leptochloa scabra*, *Leersia hexandra etc.*

After new ground has been cultivated in rice for a few times, a profitable increase in yield is obtained from a top-dressing of 100 to 200 kg of sulphate of ammonia per hectare.

Figure 10. Trail of combine harvester in soft field

Diseases and pests have made their appearance in some numbers to date, but effective control measures can usually be taken. All seed is treated with organic mercury compounds. The following diseases occur: *Piricularia oryzae*, *Neovossia horrida* and *N. oryzae*, *Cercospora oryzae*, *Helminthosporium oryzae*, *Corticium solani* and others. Only *Helminthosporium*, *Piricularia* and *Cercospora* are at times of a serious character. Insect pests include the caterpillars of *Laphygma frugiperda* and *Mocis repanta* and some bugs, of which Pentatomidae and *Mormidea* sp. are the worst; rice borers include *Rupela albinella* and *Diatraea saccharalis*. A small leaf mining fly sometimes causes damage to young crops.

Birds are sometimes very destructive, especially in young crops. Besides

seed-eaters, there are various types of water fowl including small ducks, which alight at night in great flocks on newly-sown fields. Rats are also important. Control with preparations of cumarine is usually very effective. They are also caught by hand on the bunds when all the fields are under water. One of the most costly pests is the water-snail (*Pomacea lineata*). These can destroy young seedlings over large areas of newly-sown rice, so that re-sowing becomes necessary. This is sometimes impossible, because the fields become too soft for tractor cultivation. Control with HCH and copper sulphate is effective.

Figure 11. Transport of rough rice by lighter

Dry weather at harvest is very important, because the heavy clay topsoil must become sufficiently firm to take the combines. The combines are equipped with specially lengthened and widened tracks, whereby the bearing load of the machine is better distributed. At present, sack combines are still being used, but a gradual change-over to bulk handling is contemplated. All paddy is already transported in bulk by lighters from the polder to the driers in the village.

In part of the area, depending on favourable circumstances a second crop of rice is sown immediately after the harvest. In the fallow fields, wild leguminous plants sometimes spring up; thought is being given as to how best to make use of this sort of spontaneous green manuring.

YIELDS OBTAINED

Table 1 gives a summary of the results achieved in the first two years. The record output from one plot from the cultivation of two rice crops in

Table 1. Yields of Rough Rice (14 per cent moisture content)

Season	Area Sown	Average Yield	Max. Yield (12 hectare plot)	Min. Yield (12 hectare plot)
	Ha.	Kg/ha.	Kg/ha.	Kg/ha.
Main crop 1954 ..	451	2723	3472	655
2nd crop 1954–5 ..	515	1411	2620	304
Main crop 1955 ..	1942	2974	4635	1017
2nd crop 1955–6 ..	236	2574	3828	1726
Main crop 1956 ..	*c.* 4000	—	—	—

one year amount to 6886 kg/ha. (14 per cent moisture content). Every year sowing takes place on some newly developed areas with many heaps of timber, turf, creeks and mounds, which tend to a reduction of yields.

SUMMARY

A general account is given of the Wageningen Rice Scheme. This scheme is situated in the north west of the coastal plain of Suriname, between the Nickerie river and the coast. Suriname is one of the three Guianas in the north of South America. The scheme lies in approximately lat. 5°N. The project embraces the development of 15,000 hectares of uninhabited swamp. Development is proceeding on 5600 hectares, of which 4000 hectares are already under cultivation. The scheme aims at an economic production of rice by very thorough-going mechanization. Dutch farmers are recruited as farm managers. The results obtained are encouraging. Descriptions are given successively of the organization set up for development of the operations; the aims of the plan; soils, climate and choice of crop; the layout and progress in the implementation of the plan; the organization of the agricultural service; the method of rice cultivation, and the yields of rice.

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Relationship Between Mangrove Vegetation, Soil Texture and Reaction of Surface Soil after Empoldering Saline Swamps in Sierra Leone

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Most of the Atlantic coastline of Sierra Leone consists of saline or seasonally saline mangrove swamps. The rate of development of such areas for swamp rice production has been much increased in recent years. The climate of the country has distinct wet and dry seasons; at Rokupr (9°01′N, 12°57′W) in the north west of the country about 20 miles from the sea on the Great Scarcies River, the average rainfall for the period from April to November for twenty years is 114·06 in. and from December to March is 1·26 in. Many of the rivers in the country therefore carry a large volume of fresh water during the wet season but saline conditions may extend for many miles inland during the dry season. In the case of the Great Scarcies River, for example, the salinity of the water off the furthermost island in the estuary, Kortimaw Island, falls very markedly during the wet season; a sample of water collected on 28 November 1953 contained only 860 ppm chloride ion, a value which should be compared with 16,500 ppm, normally found in sea water. On the other hand, the salinity of the water at Rokupr rises during the dry season; a water sample collected on 28 May 1954, which is not the time of maximum salt concentration, contained 840 ppm chloride; during the wet season the salt content of the river water is very low. The river is always tidal however, the tide water being fresh during the wet season and salt during the dry season.

The fluctuation of the salt content of the river water makes the conditions in the tidal swamps which border the river particularly suitable for the growth of rice. The fresh water period is long enough for a crop of transplanted rice to be grown, while the saline conditions during the dry season restrict the growth of weeds. Even on Kortimaw Island it is possible to obtain a crop of short-duration rice (approximately 160 days) which remains in the swamp between transplanting and harvesting for 100 to 120 days.

There are, however, large areas of swamp in which the level of salt is not low enough for a sufficiently long period for even a short-duration rice to be grown. These swamps may be divided into two main groups:

(*a*) Areas of poor drainage adjoining a river of the Great Scarcies type, but lying some distance from the river itself, in which salt is concentrated by evaporation during the dry season and is not sufficiently leached by the few fresh water wet season tides which are high enough to reach the areas.

(*b*) Swamps adjoining creeks or small rivers, the drainage basins of which are too small for a large volume of fresh water to flow down them during the wet season, so that the tidal water is always too saline for the growth of rice.

Different techniques must be employed in reclaiming the two types of swamps for rice production. In the case of swamps of the first type it is only necessary to improve the access of the wet season tides by the construction of channels, but in the case of swamps of the second type the tides must be excluded during the growing season of the rice and the rice grown as a rain-fed crop. This paper is concerned with problems which arise during the reclamation of the second type of swamp.

Swamp reclamation in Sierra Leone has been discussed by H. Macluskie[1]. In principle two different procedures might be followed in the reclamation of permanently saline swamps: the tidal water might be excluded at all times or only during the actual growing period of the rice and for long enough before the growing period for the rainfall to reduce the salt content of the surface soil to a satisfactory level. In fact, in swamp reclamation in Sierra Leone the first of these procedures has always been followed. This is partly due to the administrative problems which would be involved in washing the soil of an empoldering scheme of economic size (at least 50 acres) several times with rain water, and partly because experience has indicated that the level of salt in the surface soil at the end of the dry season may be such that washing, even with the whole of one season's rain, is not sufficient to reduce it to a satisfactory level. Salt concentration at the surface is often so pronounced that local farmers scrape off the layer of salty soil and sell the salt extracted from it. Generally, rice cannot be grown in an empoldered saline swamp during the first season of enclosure and, although the level of salt is usually low enough for the growth of rice after enclosure for two dry seasons, it has been shown by soil analysis that there is a further fall in the level of salt after enclosure for a third season. However, the exclusion of tidal water at all times leads to drying of the soils during the dry season, and this may produce soil conditions which are adverse to the growth of rice.

The soils of typical mangrove swamp areas of Sierra Leone were surveyed by H. C. Doyne and R. R. Glanville[2] who showed that, at least after air-drying, a soil *p*H as low as 2·2 might be found. They attributed the fall of *p*H on drying to the liberation of free hydrochloric acid, but Doyne[3], when reporting the occurrence of a similar phenomenon in Nigeria, modified his views to the belief that the acidity is caused by the oxidation of ferrous sulphide with the ultimate production of free sulphuric acid. The occurrence of low soil *p*H values after the empoldering of mangrove swamps in Sierra Leone has been reported and discussed by J. M. Dent[4]. Free sulphides do occur in some mangrove soils; an analysis of a soil from Rokupr Experimental Farm by the method of J. Smittenburg and co-workers[5] showed the presence of 900 ppm free sulphide in oven-dry soil. Soils containing sulphide have been studied extensively in recent years, particularly in Sweden, Finland, Holland and Malaya, and a scheme which accounts for the accumulation of sulphides under anaerobic conditions and their later oxidation with the production of free sulphuric acid under aerobic

conditions has been proposed by J. VAN DER SPEK[6]; and also C. L. VAN WIJK[7].

Dent has pointed out, however, that a low *p*H value does not always arise when a mangrove soil is empoldered in Sierra Leone, so that some swamps can be empoldered without adverse soil conditions resulting. In view of the incomplete understanding of the origin of the low soil *p*H values and the lack of effective economic methods for their correction when they have been produced, it is important that methods should be developed of determining if soil conditions adverse to the growth of rice will develop on drying. It has been found that the type of mangrove may often be used as a satisfactory indicator, the practice followed being to empolder land carrying *Avicennia nitida* but to avoid land carrying *Rhizophora racemosa* as far as possible. The applicability of this method of assessment has now been investigated both by

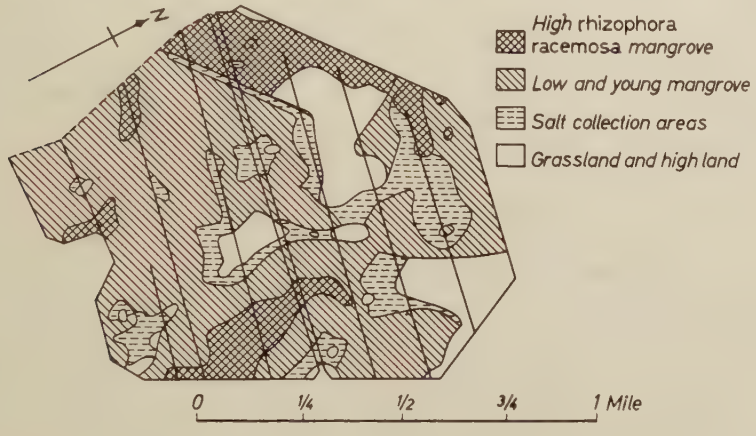

Figure 1. Mapotolon polders—original distribution of vegetation

collection of samples of surface soil from beneath various types of mangrove throughout the coastal swamps of Sierra Leone and by consideration of a particular empoldering scheme with a view to determining whether there is a correlation between the original vegetation and the present *p*H value of the surface soil.

OBSERVATIONS

The empoldering scheme considered is situated between the village of Mapotolon and the sea in the north west of Sierra Leone, about two miles south of the border with French Guinea (9°03′N, 13°17′W). It consists of two independent polders, each of an area of about 250 acres, the more northerly of which (polder *A*) was completed in the dry season of 1951–52 and the more southerly (polder *B*) in 1952–53. Polder *A* is completely surrounded by a bund, 4 to 5 ft high, and a perimeter drain; polder *B* is surrounded by a bund and drain on three sides but is enclosed by a low sand ridge on the fourth. Each polder has an internal main drain system and one sluice through its perimeter bund. The configuration of the polders is shown in *Figure 1*.

Before the completion of the empoldering scheme the greater part of the

area was not cultivated. There were, however, a few small polders of native construction, all of which were smaller than two acres in area, enclosed by bunds not more than 2 ft high, and without perimeter drains. Such polders, which are more common in adjacent swamps in French Guinea, are occasionally constructed by the farmers of the Mapotolon area to extend cultivation from the grasslands into the edges of the mangrove swamps. Also included in the empoldering scheme are higher areas, the surface soils of which had been used for salt extraction during the dry season.

Although the policy on empoldering is to exclude land carrying certain species of vegetation, particularly *Rhizophora racemosa*, it is often necessary to include small undesired areas in order to avoid the bunds being of excessive length. The empoldering scheme near Mapotolon was chosen for study because it contained almost the entire range of types of vegetation in the coastal swamps of Sierra Leone. The original distribution of vegetation before empoldering is shown in *Figure 1*, which was prepared by the examination of aerial photographs. Before empoldering the area was drained by three small creeks, the upper reaches of which are included in the polders. Excluding land which is not subject to waterlogging, either tidally or seasonally due to rainfall, the area may be considered to fall into three main divisions: grasslands; mangrove swamps; the transitional belts between. The last two of these divisions are the more extensive. The vegetation of the mangrove areas is mainly composed of the following species: *Avicennia nitida*, *Laguncularia racemosa* and three species of *Rhizophora*, *R. racemosa*, *R. mangle* and *R. harrisonii*, the main characteristics of which have been described by R. W. J. Keay[8]. A good growth of *Rhizophora racemosa* is easily distinguished on aerial photographs due to its height and is shown in *Figure 1* as ' High *Rhizophora racemosa* mangrove '. The other mangroves occur as mixed stands, although one of the species may predominate in a particular stand. *Avicennia nitida* and *Rhizophora mangle* are the more common species.

The mangroves are all low and are indistinguishable from each other and from young or poorly developed *Rhizophora racemosa* in aerial photographs; areas carrying this vegetation are shown as ' Low and young mangrove ' in *Figure 1*. This division also includes some mangrove swamp/grassland transitional areas which are characterized by the entry of salt-tolerant vegetation beneath the mangroves. The following species are the more important: *Paspalum vaginatum*, *Sesuvium portulacastrum*, *Philoxerus vermicularis* and *Fimbristylis ferruginea*; *Paspalum vaginatum* is the commonest of these. It may also be found in the grassland areas but in general these are characterized by plants the salt-tolerance of which does not exceed that of rice. The vegetation includes the following species: *Ischaemum rugosum*, *Paspalum commersonii*, *Bacopa erecta* and *Xyris anceps*, presence of the last two being taken as an indication that the area is suitable for the growth of rice without being empoldered. The ' Salt collection areas ' shown in *Figure 1* had been cleared and were usually bare of vegetation. The empoldered area also includes some small islands of higher ground. These are broken sandy ridges and generally are only a few feet above the level of the swamp; in a few places however the ridges are high enough for small settlements to be sited.

The factors which control the distribution of the different species of vegetation are incompletely understood. It is usual to find *Rhizophora racemosa* fringing creeks in almost pure stands. *Avicennia nitida* is often found on the slightly higher land away from the creek but seldom occurs as pure stands. The indications are that while *Rhizophora racemosa* makes good growth only on recently deposited heavy soils, *Avicennia nitida* is particularly salt-tolerant and grows well on rather sandy soils in which there is marked accumulation of salt during the dry season, at the end of which salt crystals are commonly found on its leaves. The grasslands are still further removed from the creeks. The soils have a high proportion of sand, commonly about 70 per cent at the surface, and are dry during the dry season.

The soils of the empoldering scheme have been surveyed twice, at the end of the dry season; in April 1954, when polder *A* had been enclosed for two years and *B* for one, and in April 1955. On the first occasion soil profiles were examined and an attempt was made to take surface soil samples which were representative of each of the five acre farming plots into which the scheme is divided. Samples of surface soil were also taken outside the polders and undisturbed soil profiles were examined. On the second occasion surface soil samples were taken at definite points inside the polders, 370 samples being taken in all, giving a sampling density of rather less than one per acre.

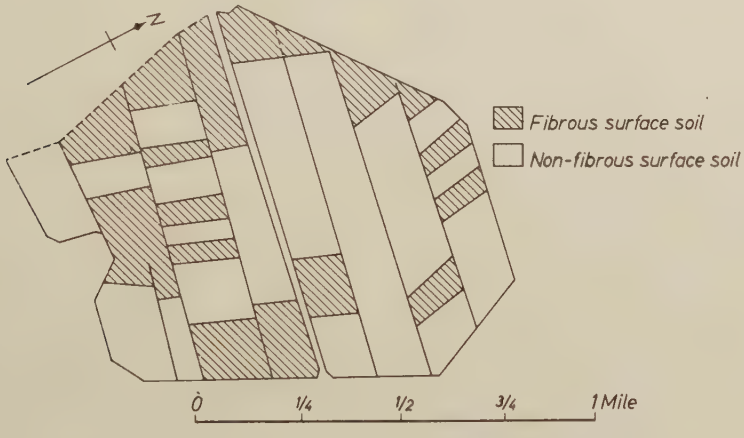

Figure 2. Mapotolon polders—distribution of fibrous surface soil

The variation of soils inside the polders is considerable. The majority of the soils are not fibrous at the surface but most of those formerly under *Rhizophora racemosa* and a belt of soils to the west and centre of polder *B*, which formerly carried low mangrove vegetation, are fibrous (see *Figure 2*) and contain between 10 and 50 per cent of organic matter, mainly fine undecomposed roots. *Figure 2* is based upon the results of the preliminary survey of 1954 and is much less precise than *Figure 1*, but comparison of the two figures shows the relationship quite clearly. The fibrous soils show no differentiation into horizons above the water table, but characteristic yellow stains, which are believed to be a basic ferric alum, are common in the profiles.

In spite of the wide variation in the mechanical composition of the remaining soils, from about 30 per cent clay in the lower soils to as low as 4 per cent in the higher ones, their profiles have many features in common. There is a dark brown-grey surface layer, of less than 6 in. in depth, underlain by a blue-grey layer, mottled with orange-yellow and often also purple stains. The mottling varies in density and in hardness; in one soil examined indurations were so numerous as to give rise to a horizon with a distinctly gravelly texture. Indurations, and stains in general, are associated with old root channels. With increasing depth, the indurations and stains become less common and the colour of the soil changes to a darker blue. The majority of the soils are sandy at depth and the water table was saline in 1954. The *p*H value of the soils always increases with depth within the polders. At the time of sampling there was a slightly higher content of chloride at the surface of the soil than immediately below it. The profile of a soil of polder *A* which is typical of the general trends is described in *Table 1*.

The soils immediately outside the polders are generally similar to those inside except that the surface grey-brown horizon may be very shallow. The *p*H value of these soils also increases with depth.

Table 1

Depth	*Description*	*Soil Samples*		
		Depth in.	*p*H	Cl·*ppm* (*wet soil*)
	Surface bare			
0 *to* 14 *in.*	*Top soil grey-brown matrix, mottled orange and yellow; mottling does not stop at any definite point but is rare below* 14 *in.*	7–9	4·45	8700
14 *to* 35 *in.*	*Matrix changes gradually to blue-black sand not noticeably mottled but containing indurated particles giving a slightly gravelly texture; the number of these decreases with increasing depth*	21–24	5·4	8500
More than 35 *in.*	*The hole filled with slightly brackish water to* 35 *in.; the ground-water table was probably higher than this*	33–36	7·7	10,500

The surface soil samples taken during the survey of April 1955 were stored in air-tight glass bottles until they were examined in the laboratory. The *p*H values of all the soil samples were determined within six days of collection, the determinations being made using an approximately 2 : 1, water : soil suspension and a Cambridge portable *p*H Meter. The accuracy of the determinations is about $\pm 0{\cdot}5$ units, and it was shown that storage of the samples for a further 30 days did not produce a change in the value greater than this. The values found were in the range *p*H 2·04 to 8·08. The distribution of *p*H over the polders is shown in *Figure 3*, which may be compared with *Figures 1* and *2*.

Taking account of the low sample density, by comparison with *Figures 1* and *2* it will be seen that there is a good correlation between areas of low

surface *p*H and those which formerly carried *Rhizophora racemosa*. Over 50 per cent of the areas formerly under this mangrove have a surface *p*H below 3·0 and almost all have a surface *p*H below 4·0. The converse relationship does not hold however, the most important exception being the area in the south of polder *B* which formerly carried low mangrove. The surface soils of this area are however distinctive in being fibrous, and comparison of *Figures 2* and *3* shows that there is a very good correlation between areas of low surface *p*H and those which have fibrous surface soils. Areas of high *p*H are generally associated with high relief, but there is not so close a correlation between them and the original vegetation. Where high *p*H values are not associated with village sites, they usually occur in areas which were cleared or were used formerly for the collection of salt. This distribution may occur because the areas chosen for salt collection are usually the driest in the dry season, *i.e.* the highest.

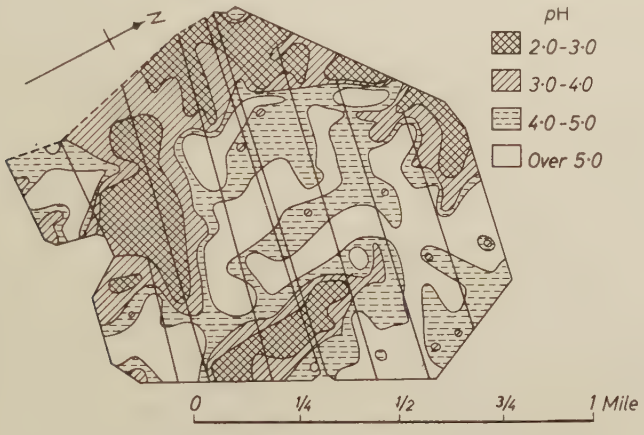

Figure 3. Mapotolon polders—surface soil pH values, April 1955

The mangrove swamps of the Mapoloton area are of recent formation, the appearance of new islands in the main Scarcies delta being noticeable over as short a period as 10 years. It is possible therefore that the relationships which are found in these swamps may not be typical of the coastline of Sierra Leone in general. Soil samples have therefore been collected beneath the various mangrove species at many points along the coastline. Samples of surface soil were taken and stored in air-tight bottles until examination. After determination of the fresh *p*H value, the soil samples were allowed to dry in beakers for at least two months and the *p*H values were then redetermined. It has been shown that on drying under these conditions the *p*H may fall for about 30 days, after which the value remains approximately constant. The behaviour of the soil samples on drying is summarized in *Table 2*. A value of *p*H 4·0 was chosen as critical since it has been shown that the growth of rice is severely restricted in soils of this *p*H and that grain formation is prevented. In no case was the value of the fresh soil *p*H below 4·0. The textures of the soil samples were classified qualitatively as ' fibrous ' or ' non-fibrous ' and the soils are considered in these groups in *Tables 2* and *3*.

Table 2. Fibrous soil samples

Vegetation	*Total No. of samples*	*No. of samples of pH less than 4·0 after drying*	*Samples of pH less than 4·0 after drying %*
Rhizophora racemosa	9	5	56
Rhizophora harrisonii	3	3	100
Avicennia nitida	7	4	57
Total	19	12	63

Table 3. Non-fibrous soil samples

Vegetation	*Total No. of samples*	*No. of samples of pH less than 4·0 after drying*	*Samples of pH less than 4·0 after drying %*
Rhizophora racemosa	10	0	0
Rhizophora harrisonii	6	1	17
Avicennia nitida	16	2	12
Total	32	3	9

The interpretation of these data is influenced by the small total number of soil samples which renders the percentages calculated imprecise.

DISCUSSION

The data summarized in *Tables 2* and *3* show that the relationship between original vegetation and the surface soil *p*H value observed at Mapotolon is not typical of the coastal swamps of Sierra Leone in general. When the swamps as a whole are considered, it is clear that soil texture is a more reliable indicator of the occurrence of surface acidity after drying than is vegetation. The relationship between soil texture and low surface *p*H value after drying is obscured in the case of the Mapotolon polders by the fact that the majority of fibrous soils carry high *Rhizophora racemosa*. However its applicability in this case is also seen by consideration of polder *B* in which the belt of fibrous soils which is acid after drying was not originally under *R. racemosa*. It should also be remarked that it is unusual for fibrous surface soils to be found under *Avicennia nitida*, so that the choice of areas under this mangrove for empoldering in effect is often the same as the choice of non-fibrous surface soils.

The reason for the relationship between fibrous surface soils and low *p*H values after empoldering and drying cannot be stated with certainty. The fibrous nature of the surface soil is probably due to an accumulation of undecomposed fine *Rhizophora* roots. It is probable therefore that low *p*H values only develop after drying of soils on which *Rhizophora* spp. have grown over a period of some years and in which, if the *Rhizophora* has been succeeded by other vegetation, soil conditions have not been suitable for decomposition of the original root mat. The distribution of vegetation at Mapotolon clearly indicates that high *Rhizophora racemosa* is found in the lowest areas. These areas are those most likely to be permanently waterlogged and it is probable that the accumulation of the sulphides, which on oxidation give rise to low *p*H, is slow and that a high concentration can only be built up under permanently anaerobic conditions. It may be that permanently anaerobic conditions are also necessary for accumulation of

fibrous roots in the soil and that a change to aerobic conditions in a fibrous sulphide-containing soil would lead both to oxidation of the sulphides present and decomposition of the fibrous roots. If the original *Rhizophora* vegetation were succeeded by other species and the soil remained anaerobic, the accumulations of sulphides and fibrous roots would not be destroyed. There is a tendency for *Rhizophora racemosa* to be succeeded by other mangrove species, for the best specimens of the mangrove are always found on fairly recent deposits along the edges of creeks. This may be due to a high nutrient demand of *R. racemosa* or, as has been suggested by D. R. Rosevear[9], to the difficulty of the establishment of its seedlings in the fibrous soil. In connection with the first of these explanations it is of interest that it is the belief of the local farmers in Sierra Leone that the best crops of rice are obtained from soils formerly under *R. racemosa*, such soils not being empoldered and allowed to dry in normal farming practice.

The factors which control the distribution of the mangrove types are not completely understood, but *Avicennia nitida* is generally associated with those areas in which salt is accumulated during the dry season. In these areas there is upward movement of water during the dry season and the surface of the soil is aerobic so that soil conditions are not suitable for the accumulation of sulphide or for the maintenance of high concentrations if these exist already.

CONCLUSION

Fibrous mangrove soils should not be empoldered and allowed to dry. Generally speaking such soils will be found under a cover of *Rhizophora racemosa*, but they may carry other mangrove species and, alternatively, soils under *Rhizophora racemosa* may not be fibrous. The selection of areas for empoldering in Sierra Leone cannot therefore be made by consideration of the vegetation alone. The vegetation may give a useful preliminary indication but the soils themselves should always be surveyed before a final decision is taken.

SUMMARY

The results of a study of relationships between vegetation soil texture and the development of acidity on drying swamps soils in Sierra Leone are reported. One empoldering scheme is considered in detail and the results of its study are compared with those obtained by studies of soil samples collected in a number of coastal swamps. It is concluded that, while vegetation may often give a preliminary indication of the suitability of swamps for empoldering, a more reliable indication is given by the texture of the surface soil. Soils which are fibrous due to the accumulation of undecomposed fine roots should not be empoldered and allowed to dry.

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Effect of Krilium *on* Zea Mays *L. Grown in Two Tropical Soils*

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In order to secure maximum plant growth it is very important to establish and maintain a friable condition in soils. The formation of aggregates which lead to this condition is dependent upon three factors: the presence of colloidal particles that may be aggregated, the flocculation of these particles, and the cementation of the coagulated material into water-stable aggregates. In nature, the formation of the granular condition most favourable for plant growth is governed primarily by the humus content of the soil.

The announcement in 1951 of the development of synthetic materials which would improve soil structure created great interest among soil scientists. R. M. Hedrick and R. M. Mowry[1] reported that the *Krilium** formulations CRD-189 and CRD-186 increased soil aeration and greatly increased aggregate stability. W. P. Martin and co-workers[2] reported that these same two synthetic soil conditioners increased soil aggregation, porosity, and permeability. The aggregates were found to be water-stable, the structural improvement persisting through the second growing season. Not all crops tested by these workers responded to *Krilium* treatment of the soil. Corn yields, however, were increased significantly when *Krilium* at 0·02 or 0·1 per cent was incorporated into the soil with a disk or with a rotary cultivator. The addition of vinyl acetate-maleic acid copolymer (*VAMA*) to a poorly aggregated soil nearly doubled the growth of avocado seedlings. The same material had no effect when added to a well-aggregated soil[3].

J. D. De Ment and co-workers[4] tested several synthetic soil-aggregate stabilizers and found that the chemicals reduced soil crusting. These workers also obtained increased emergence of plants in three of the five tests conducted.

The present experiment was initiated to determine the effect of *Krilium* on germination, growth, and yield of corn (*Zea Mays* L.) grown in two tropical soils.

PROCEDURE

A Latin square design with four treatments replicated four times was set up on each of the following two soil types: Catalina clay, located near Mayaguez, and Corcega sandy clay, located near Añasco, Puerto Rico. The site at each location was ploughed to a depth of 6 in. and cultivated with a disk harrow. When the soil was moist to approximately field capacity *Krilium* was broadcast by hand over the appropriate plots at the

* A synthetic polyelectrolyte soil conditioner manufactured by the Monsanto Chemical Co., Midland, Michigan, U.S.A.

rates of 0, 500, 1000, and 2000 lb./acre. Commercial fertilizer (analysis 10-10-8) was broadcast over the area at the rate of 500 lb./acre. The plots were then cultivated thoroughly with a rotary cultivator to a depth of 6 in.

Each plot measured 15 by 20 ft. and consisted of five rows 3 ft. apart, with 10 hills of *Zea Mays* L., variety USDA-34, set 2 ft. apart. Five kernels of corn were planted in each hill. The percentage germination was determined when the plants were 6 to 10 in. tall, after which they were thinned to two per hill. Applications of 2 per cent chlordane and 5 per cent

Table 1. Average percentage germination of USDA–34 sweet corn grown several times on two soil types treated with Krilium*.

Treatment	Corcega sandy clay†		Catalina clay‡		
	Date counts made		Date counts made		
	23 December 1952	30 December 1953	5 November 1952	30 June 1953	17 February 1954
	Per cent	Per cent	Per cent	Per cent	Per cent
No Krilium (*control*)	66·8	81·1	76·8	88·5	63·0
Krilium 500 *lb./acre*	74·5**	90·6	76·1	90·6	66·5
Krilium 1000 *lb./acre*	74·4**	92·0	75·8	92·3**	63·6
Krilium 2000 *lb./acre*	78·5***	95·3	68·6	90·1	68·9**
Significant difference of means:					
5 per cent level	7·5	17·2	9·2	2·8	4·9
1 per cent level	11·4	—	—	—	—

* Average of 4 replications. † Krilium applied 24 Oct. 1952. ‡ Krilium applied 17 Oct. 1952.
** Significant at the 5 per cent level. *** Significant at the 1 per cent level.

wettable DDT to control insects, mainly cutworm and corn earworm, were made as necessary. Each planting received a side dressing of ammonium sulphate at the rate of 150 lb./acre when the plants were four to six weeks of age. The average yields in fresh weight per plot of ears plus plants was recorded at maturity. Observations were also made on the growth and time of flowering of the plants.

Since the synthetic soil conditioners are reported to have a long-lasting effect on the soil, corn was planted at Añasco on 4 December, 1952, and 17 December, 1953. At the site near Mayaguez, plantings were made on 17 October, 1952, 10 June, 1953, and 20 January, 1954. To avoid any temporary improvement of soil structure due to rotary cultivation, this process was not used after the original incorporation of the *Krilium* into the soil. For all later plantings, the seedbed was prepared by hand-hoeing. J. Hagin and G. B. Bodman[5] have reported that mechanical mixing of soils to which CRD-186 had been previously added diminished the influence of the soil conditioner.

RESULTS AND DISCUSSION

The germination of the first crop grown on the Corcega sandy clay was significantly higher than the control in all *Krilium* treatments and highly significant at the 2000 lb. rate (*Table 1*). The improvement in germination was attributed to better soil aggregation, which permitted the hypocotyls to emerge more readily than in non-treated soils. Significant differences in germination, however, did not occur in the planting made one year after the *Krilium* was originally incorporated into the soil. The first crop planted in the Catalina clay soil did not show significant differences in percentage germination. Corn germination was improved significantly at the 1000 lb. rate for the second crop, and at the 2000 lb. rate for the third crop.

Corn yields of plants grown in Catalina clay soil were lower than those grown in Corcega sandy clay. These lower yields were partly attributable to low rainfall. The increase in grain yield in the first planting in the Corcega sandy clay soil near Añasco was significant at 1000 lb. and highly significant at 2000 lb./acre of *Krilium* above the average check plot yield (see *Figure 1*). In the second crop, all plots treated with *Krilium* yielded significantly greater amounts of grain than did the non-treated plots. Although physical measurements were not made on the soil, observations showed that applications of *Krilium* to the Corcega sandy clay greatly improved aggregation. At the end of one year it was possible to pick out each plot that had received *Krilium*. At that time the control plots showed little surface aggregation; whereas the treated plots showed aggregation—the higher the rate of *Krilium* application, the greater the amount of soil structure improvement. Since improved soil structure would permit greater ramification of the root system, it is probable that roots of corn plants grown on plots treated with *Krilium* were able to utilize available soil moisture and mineral elements better.

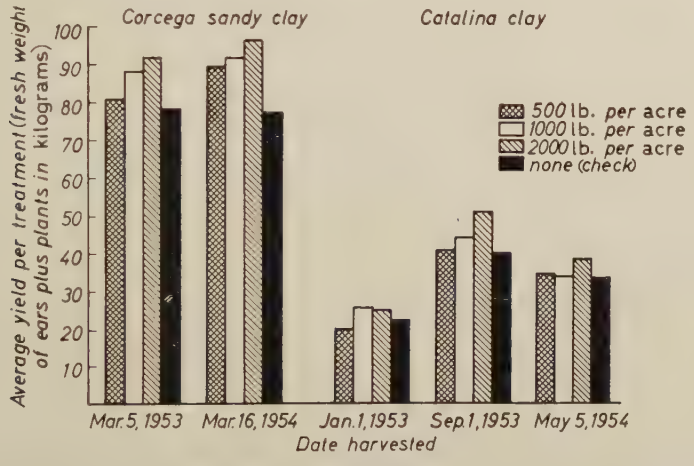

Figure 1. Effect of Krilium *applications on yield of corn grown on two soil types, Corcega sandy clay and Catalina clay*

Yields of corn plants grown on the Catalina clay soil not only were lower than those of plants grown on the Corcega sandy clay, but also differences between treated and non-treated plots were less. In the first crop, plots treated with *Krilium* did not yield more than the control plots. The 1000 and 2000 lb./acre plots, however, yielded significantly greater amounts of grain than the plots treated with 500 lb./acre. In the second crop, only the plots treated with *Krilium* at the rate of 2000 lb./acre yielded more than the control plots, and in the third crop yield differences were not significant. Although the Catalina soil has a higher clay content than the Corcega soil, visible differences in structure of the former due to *Krilium* application were not apparent. The lack of significant yield differences by the third crop suggests that the effects were not lasting.

Observations were made on the time of flowering and ear maturation at both locations. With the first crop grown on the Corcega sandy clay soil, the plants grown on the plots treated with *Krilium* blossomed and matured ears approximately one week earlier than did the plants on the check plots. Such differences did not occur for the second crop on this soil type, nor for any of the crops grown on the Catalina clay soil.

At the present time *Krilium* is an expensive soil amendment. Even if the material cost only 10 cents per pound, the cost of the chemical plus labour for application would exceed 200 dollars per acre for the highest concentration. Thus, under the conditions of this experiment, it can be concluded that on neither soil type were the increased germination and yields due to *Krilium* application sufficient to justify the purchase and application of the material.

SUMMARY

Krilium, a synthetic soil conditioner, was applied at the rates of 0, 500, 1000, and 2000 lb./acre to two Puerto Rican soil types, Corcega sandy clay and Catalina clay. Applications of the material to Corcega sandy clay soil resulted in significantly higher percentage corn germinations and yields than the check plots. Hastened blossoming and ear maturation also occurred for the first crop grown after *Krilium* was applied. The aggregation of this soil type was improved for a period of more than one year after *Krilium* application.

Yields of corn on plots of Catalina clay soil treated with *Krilium* were improved, but the effect was less with each successive crop. Significant yield differences did not occur by the time of the third harvest, 18 months after the soil conditioner was applied. Aggregation of this soil was not visibly improved by application of the chemical. On neither soil type were the increased germinations and yields due to *Krilium* applications sufficient to justify the purchase and application of the material.

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A Thermocouple Spear for Temperature Measurement in Stacks of Bagged Produce

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A large percentage of the food and agricultural produce of the world is stored in bags which are built into stacks. This practice is followed because it is easier to handle small quantities in this manner and also capital does not have to be invested in expensive handling equipment and storage structures which are necessary for bulk storage. It is well known that, when produce is stored in bulk, it is advisable to ascertain the temperature prevailing in the bulk in order to take remedial action if undue heating occurs. Similarly it is advisable to ascertain the temperature prevailing in a bagged stack.

The only equipment at present available for measuring temperatures in bagged stacks, which have not been specially prepared for such measurements, is a short spear enclosing a thermometer. Thus only the temperature of the peripheral bags, which are in the best position for losing excess heat, can be ascertained without, at least partially, breaking down the stack.

A demand therefore exists for a temperature measuring apparatus which can be used to determine the temperature of stored produce near the centre of a stack without breaking it down. A thermocouple spear has been developed for this purpose because:

(*a*) The temperature measuring junction can be relatively small.

(*b*) A satisfactory voltage : temperature relationship exists.

(*c*) The measuring instrument, *i.e.* the potentiometer, can be connected to any practical length of the thermocouple wire and the above relationship still exists.

(*d*) A satisfactory field potentiometer has been developed from the commercial Doran mini potentiometer.* The main changes which have been made to the original wide range model are as follows: *i*, the slide wire dial has been enlarged; *ii*, a polarity reversing switch has been included; *iii*, one terminal has been mounted in a brass block insulated from the facia panel and has been provided with a horizontal hole to take the bulb of a straight thermometer. This terminal is negative when the reversing switch is in the positive position. The Eureka wire is connected to this terminal which is thus equivalent to the ' reference junction ' of a normal thermocouple apparatus; *iv*, the terminal knobs are made of a thermally non-conducting material; *v*, the instrument is tropicalized.

* Made by Doran Instruments, Ltd., Stroud, Gloucestershire.

If it is desired, however, an electrical resistance thermometer such as a thermistor could be incorporated. It has the advantage of being direct-reading. Also the null point instrument can be less sensitive than in a potentiometer without reducing the accuracy of the temperature determination and this allows the use of a thicker indicating pointer. The main disadvantage of this type of instrument is that if either of the leads is broken near the thermistor, or the thermistor itself is damaged, the instrument *in toto* has to be returned to the manufacturer for repair and recalibration.

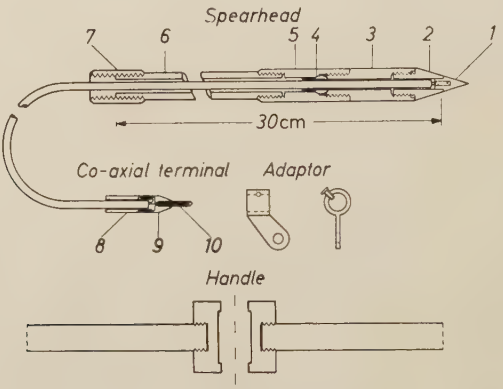

Figure 1

In order to protect the thermo-junction which is inserted into the stack, it is incorporated into a brass spearhead but thermally insulated from the main body of the spearhead by *Perspex* which forms a portion of the spearhead. Only a small volume of brass, forming the actual point of the spearhead surrounds the thermo-junction so that its thermal capacity remains small. Thus the temperature of the produce is not greatly affected by the brass, in addition, the time taken for the temperature of the thermo-junction to equilibrate with the temperature of the produce is as short as possible. The thermocouple wires (copper and Eureka) which lead from the thermo-junction are covered in polyethylthene. In another form of the cable this is braided in mild steel wire before a final coating of polyethylthene is applied.

In order to insert the spearhead, lengths of metal piping are attached to it, the thermocouple wire being first threaded through the piping which protects the wire from damage. After considering the rigidity, strength and availability of standard piping, it was decided that the minimum outside diameter for a spear would be about 0·5 in. The insertion and withdrawal of such a diameter spear, using the special handle, proved to be relatively easy when tested on twill sacks containing barley which had compacted during storage*. The rupture of the stacking when the spear had been inserted and withdrawn was not excessive and is, of course, unavoidable. For ease of gauging the depth to which the thermo-junction has been inserted, the lengths of metal piping comprising the shaft are made 30 cm in length and are joined by steel couplings.

* Inserted to a depth of 8 ft which was the maximum depth available.

DESCRIPTION

The spear (*Figure 1*) consists of: a spearhead, a shaft, a co-axial terminal and a handle.

Spearhead—The brass tip *1* incorporating the thermo-junction is a press fit in the perspex insulator *2*. These two parts are then machined together to an included angle of 35°. Thus a smooth union between the brass tip and the insulator is obtained. The length of the brass tip is 0·5 in. and that of the insulator is 0·6 in.

The insulator screws into the first part of the body *3*. The latter is 2·25 in. in length and 0·68 in. outside diameter. The second part of the body *5* also 0·68 in. outside diameter, is 1·75 in. long and is so shaped that the internal steel split collett *4* holds the thermocouple wire firmly when the two parts of the body are tightly screwed together. The shaft end of the second part of the body is chamfered down to the outside diameter of the shaft. The remainder of the spearhead is nominal $\frac{1}{4}$ in. gas piping *6*, external diameter 0·532 in., which screws into the body. The length of the spearhead is such that the thermo-junction included in the brass tip *1* is 30 cm from the end of the gas piping.

Shaft—The shaft is composed of 30 cm lengths of $\frac{1}{4}$ in. gas piping joined by turned down and chamfered steel couplings *7* with an outside diameter of 0·65 in.

Co-axial Terminal—The design of this connector is co-axial so that it can be easily threaded through the lengths of piping before these are connected to the spearhead or shaft. A special adaptor is necessary to connect this terminal to the normal screw cap terminals on a potentiometer; it is designed to bring the inner (forward) part of the connector, which terminates the Eureka wire, into the closest possible thermal contact with the ' reference junction ' terminal.

The thermocouple wire is led into a brass sleeve *8* which has an overall length of 1·5 in. and an outside diameter of 0·31 in. with a $\frac{1}{4}$ in. by $\frac{1}{4}$ in. spigot. The copper wire is laid bare and connected to this sleeve. A red fibre insulator *9* about 0·5 in. long with a plain diameter of 0·31 in. is a press fit on to the spigot of the sleeve. The Eureka wire is connected to a 0·08 in. diameter monel capillary *10* which is a press fit into the red fibre.

Handle—The handle consists of two brass blocks each 6·5 cm by 2·0 cm by 3·5 cm hinged together along the latter edge so as to form, when closed together, a composite block 6·5 cm by 4 cm by 3·5 cm. A spring latch is provided to hold the two halves of the block in a closed position. Two steel side arms, each approximately 6 in. long, are screwed into the composite block, one in the middle of each of the two outer faces of the composite block.

The composite block is bored, parallel with the hinge, along the mid line of the contiguous faces of its two halves, with a hole to clear $\frac{1}{4}$ in. gas piping. This hole is enlarged, except for 5 mm at each end, to take a coupling. For inserting or withdrawing the spear, this handle is latched round a coupling joining two lengths of shaft and pressure is applied to the side arms.

SUMMARY

The design of the thermocouple spear to determine the temperature of a bagged commodity at depths down to about 20 ft in a stack is described.

The spear itself is tripartite consisting of: *1*, a spearhead of 0·68 in. outside diameter with an insulated brass tip enclosing the thermo-junction; *2*, the shaft of 30 cm lengths of nominal $\frac{1}{4}$ in. gas piping joined by chamfered steel couplings (outside diameter 0·65 in.); *3*, co-axial terminal; the spear is inserted and withdrawn from the stack using a special handle which is described.

ACKNOWLEDGEMENTS

This work formed part of the programme of applied research of the Pest Infestation Laboratory and is published by permission of the Department of Scientific and Industrial Research. The authors wish to thank Mr D. W. Hall, Colonial Liaison Officer who initiated this work and Mr M. A. Cordaroy, Instrument Maker, who constructed the instrument from theoretical diagrams.

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Earthing-up of Gros Michel Bananas

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In 1948 Professor C. W. Wardlaw, of Manchester University, drew attention to the extent to which in the British Cameroons from five to nine inches of the root-bearing region at the base of the banana stem stands exposed above soil level, devoid of roots[1]. He considered that this condition was due to: ' cultural malpractice consisting in pruning away unwanted suckers with the machete and/or to cleaning operations away from the plant,' and that it may result in a loss of as much as 50 per cent of the potential root system.

A typical exposed stem base is shown in *Figures 1* and *2*. This condition could also be due to top-soil erosion or to soil wash caused by rain water running down the stem. Before the war earthing-up was a routine practice in *Musa textilis* cultivations in Indonesia. When therefore banana fertilizer experiments were initiated by the Research Division of the Cameroons Development Corporation in 1953 earthing-up was included among the treatments. Earthing-up means making a mound of earth round the base of the banana plant in a circle of about 18 in. radius, so that the root-bearing region is covered to a depth of from 4 to 6 in. (*Figures 3* and *4*).

It appeared that erosion in consequence of water running down the plant was reduced by not ramming down the mounds. As a further measure against erosion, trash was placed around the perimeter of the mound. It has been found that this mulch also helped to conserve moisture during the dry season. From the seasonal point of view, it is advantageous to have the mounds completed before the end of the rains and four months before the blow-down season.

The cost of carrying out the initial earthing-up is approximately six man-days per acre. The cost of maintaining the mounds depends to a great extent upon the type of soil and the rainfall. Mounds in areas with sandy soils need more frequent maintenance than those containing a higher clay content.

It was suggested that the new suckers in earthed-up mats would appear on the top of the mounds and that the result would be worse than the initial condition. Experience gained on this aspect shows that up to the present time, that is after two years, suckers do not appear on the tops of the mats but around the perimeter as before. It is considered that selective pruning methods will keep this problem under control (*Figure 5*). Four months after being earthed-up it was found that the once exposed root-bearing region had formed a mass of new roots. It further appeared that root growth is not confined to the mound, but that the roots penetrate into the undisturbed ground (*Figures 1* and *6*).

In a recent article on wilt of bananas J. Rishbeth[2] states that infection by *Fusarium oxysporum* f. *cubense* is most likely to occur through healthy rootlets

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

and not through wounded roots. It seems therefore that the root damage which occurs during earthing-up is not likely to increase Panama disease.

Particularly at the beginning and to a lesser extent at the end of the rains, storms are liable to cause severe damage. The losses suffered during these blow-downs take two forms. The stem may break at a variable height above ground level (break-neck) or it may be pushed over (uprooted). With break-necks the root system of the mat is not disturbed and sucker regeneration is rapid. When plants are uprooted it is necessary to replant the stand, which is an expensive process and leads to a slower recovery. Earthing-up has proved successful in reducing the number of trees uprooted and of the total number of losses due to windstorms. In 1955 the results in plots that had been totally earthed up were: 44 uprooted and 599 break-necks; in 1956 26 uprooted and 1027 break-necks. Results for earthed-up and not earthed-up plots are given in *Table 1.*

Table 1. Comparison between earthed-up and not earthed-up plots

Type	*Earthed-up*		*Not earthed-up*	
	1955	*1956*	*1955*	*1956*
Uprooted	47	1	973	158
Break-necks	697	141	417	45
Total	744	142	1390	203

It can be seen from these figures that the number of uprooted trees is reduced considerably. Consequently the costs involved in re-supplying will

decrease. Also a quick regeneration from established mats is attained (*Figure 7*). In addition, it appears that total losses due to windstorms are 30 per cent to 50 per cent less in the earthed-up plots.

Trials laid out to investigate the possibilities of extending the present replanting cycle indicate that earthing-up, through its effect on increased efficiency of the root system and on reduction of the number of uprooted trees due to windstorms, may increase this period by several years. Although results are not yet available on the growth response of banana plants whose root systems have been increased by earthing-up, it has been found that earthing-up reduces losses due to drought in the dry season.

ACKNOWLEDGEMENTS

My thanks are due to the Management of the Cameroons Development Corporation for permission to publish this communication and to Mr L. A. Sanders, Agricultural Supervisor, for his valuable advice and encouragement. I am indebted to Mr J. West, Plant Pathologist, for his comments on the manuscript. I must also gratefully acknowledge the work of those officers of the Research Division who assisted in recording these experiments.

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Grafting Tomato to Resist Bacterial Wilt

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Bacterial wilt is a major disease of tomato in British Guiana. Each year it affects the acreage under cultivation and reduces the output of fruits. Sometimes, entire cultivations are wiped out by this soil-borne organism. In the absence of a wilt-resistant strain of tomato or an effective fungicide, grafting tomato scions on related, indigenous plants was tried at the agricultural station at Hosororo in the North West District. Cultivation by this means has proved so successful that the practice is being adopted by local truck gardeners.

ROOTSTOCK

Solanum demerarense Dem. and *Solanum juripeba* Rich. are used as rootstocks. These thorny shrubs, popularly known as 'burro-burro', withstand very severe weather and soil conditions and mature rapidly. They grow abundantly and are known to be wilt-resistant. Young plants, 6 to 8 in. high, are collected from the immediate vicinity and put out, 3 ft apart, on prepared mounds. They are afterwards given normal care and attention—watering, manuring, clipping of side shoots—for about two months. At this stage they are roughly four months old, about 18 in. high, and provide good stocks. After selection for sturdiness and straightness, the burro-burro plant is freed of all leaves and lateral growth. The crown is then completely cut off, 8 to 10 in. from the base and just below a node. Next, the stock is split across the centre to a depth of 1 in. to accommodate the scion.

PREPARATION OF SCION

Tomato seedlings four to five weeks old and about 12 in. high grown in boxes containing sterilized soil, wood ash, charcoal, *etc.* (fresh soil and manure are not included) and watered with a $2\frac{1}{2}$ per cent solution of nitrogen, phosphorus and potassium (2 : 1 : 1) are used to furnish suitable scions. In the preparation of scions, the terminal portion of the tomato plant is cut off just above a node at that point where its circumference is about equal to that of the prepared stock. This is then freed of all leaves and the base pared on both sides to form a wedge 1 in. long. Optimum results are obtained from scions 5 to 6 in. long, firm to the touch and free of hardwood or fibre.

WEDGE GRAFT

The scion is then inserted in the stock making a wedge graft and this is held securely in position by binding with raffia. Shade is provided for a few days, and also water if necessary. Approximately 95 per cent of the grafts are successful. Under average conditions, union is complete within 14 days and the degree of compatibility is, in all cases, satisfactory. As growth of the cambium proceeds, the binding material is loosened,

burro-burro side shoots are suppressed, and supports are provided. The growing scion is then trained into the system of bush culture desired. Grafted tomato plants produce several crops and the fruits are ready for harvesting in the usual 11 to 12 weeks.

ACKNOWLEDGEMENT

Acknowledgement is made to Mr A. F. Mackenzie, Director of Agriculture, British Guiana, who suggested the preparation of this note and with whose kind permission it is published.

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Book Reviews

NIGERIAN COCOA FARMERS

R. Galletti, K. D. S. Baldwin and I. O. Dina. Oxford University Press : London, 1956. xxxix + 744 *pp.* (illus.) 105*s*

The thickness of paper used in this book makes it an even more forbiddingly large tome than many of its length, and the price will deny it to many potential readers. This is a pity, because there is very good material in it. The survey which it describes was financed by the Nigerian Cocoa Marketing Board, planned in England by a committee including several agricultural economists, and carried out by a staff supervised by the co-authors, during 1950–53.

The survey was not organized according to proper statistical precepts of randomization, owing to the necessity of concentrating on areas where good cooperation could be obtained; a very understandable limitation when it is realized that the questionnaires included such subjects as income and expenditure, on which not every African farmer is very forthcoming.

The bulk of the book is taken up with two parts, at the end of each of which the authors have helpfully inserted a summary chapter recalling the main findings. The first of these parts deals with the general agricultural, social, and economic background of the cocoa farmer's life. It is open to the criticism that, while only relatively short accounts of such subjects as land tenure and nutrition could be included, much more detailed accounts of these aspects of Nigerian life can be found elsewhere, and indeed are largely drawn upon in the treatment in this book. In this part the reader may feel that there is little that is new or original. But the writing is fluent and commendably free of technical and economic jargon.

The second part, on the other hand, is impressive and shows at its best the application of economic analysis to production of a tropical cash crop. All the matter is original and interesting, but some parts in particular shed new light on old problems. One such is the masterly discussion on profits per hour of labour per acre expended by the peasant on his crop, or in other words on the optimum intensity with which the crop should be cultivated. Another is the analysis of the relative efficiency of the three main food crops of the cocoa-farming region in producing calories and money value per acre. The treatment of peasants' income is outstandingly complete and lucid for this type of material. In contrast, the analysis of the operations of some particularly successful farmers on pages 347 to 364 does not seem to achieve quite as much as it promises.

As to sins of omission, the reviewer cannot be critical, for he has to confess that he has not read every word of this book. Being a busy man, he has not had the time to. He fears that the same will apply to many who might profit by reading it.—G.B.M.

SUGAR CANE AROUND THE WORLD

A. H. Rosenfeld. University of Chicago Press: Chicago, 1956. 562 *pp.* $6.50

This book is a notable contribution to the science of sugar cane culture. Readers must, however, bear in mind that though this book has been printed in 1956, it was written and finished in 1941; indeed the most recent reference quoted is dated 1936.

The book is therefore very much out of date and a good many of the statements made would have to be changed in the light of more recent work and experience. For this reason it is not a book one would refer to for factual information of a technical nature. Its main value is historical and there is a great deal of interest in the descriptions, by a man, internationally known in the sugar world between the two world wars, of how things used to be done in the various sugar growing areas. From these descriptions one is able to trace how modern practices have been developed, as for example weed control by spraying. At that time arsenic was the substance used and while this is a far cry from the numerous different materials which are now available, nevertheless the principles stated would still hold today.

The two most notable chapters in this book are those dealing with the practical aspects of cane cultivation: preparation, drainage and irrigation, and planting and cultivation practice. In the latter final chapter there is a long quotation by Agee on ' Plantation Strategy ' which is the highlight of the book. It is most disappointing that all references to this last chapter have been omitted to expedite publication.

Dr P. Honig in his introduction has aptly summed up the value of the book. ' I am convinced that it is worth while for all technologists who are dealing every day with the problems of economic cane production to become acquainted with the experiences and views of Dr Rosenfeld because I know that the study of a serious mind with great knowledge will always enrich our own knowledge and we will benefit from it in some way '. There is no doubt that we will.—J.S.C.

STATISTICAL METHODS FOR AGRICULTURAL WORKERS

V. G. Panse and P. V. Sukhatme. Indian Council of Agricultural Research: New Delhi, 1954. 361 *pp.* (illus.) Rs 15; $5.70

This book is as welcome for its comprehensive coverage of general statistical methods and the design and planning of experiments as for the simple but thorough treatment of the subject matter. The volume is essentially a handbook of the statistical methods and designs most commonly required by agricultural research workers. It is for those of modest mathematical attainments, only sufficient theory being given for an intelligent appreciation and application of the methods. The approach is practical throughout; actual data are helpfully discussed and used to explain and illustrate the methods. In some cases, however, the examples are rather large for the reader to check through readily himself. A selective list of references is given at the end for further reading, but these might have been rather more closely associated with the text, especially where results are quoted. The style is direct, readable and of a conversational tone, if at times somewhat

colloquial. The attention of the reader is constantly directed to fundamental or difficult points while useful computational hints are to be found throughout the text and also in a convenient appendix.

The usual topics of distributions, standard errors, tests of significance (including the analysis of variance) correlation and regression are discussed in the first part. In addition, there is a substantial chapter on χ^2 and the estimation of linkage. The principles and the simpler types of experimental design are covered, including the more straightforward confounding of factorial experiments together with split-plot and strip-plot designs. Then follows a chapter on the analysis of covariance and its application in the analysis of experiments with missing plots. The more common designs for use in plant breeding work are dealt with in the next chapter, where simple and balanced lattices are introduced. The importance of series of experiments is reflected by devoting chapters to the design, choice of treatments and selection of sites for experiments on cultivators' fields and to the analysis of groups of experiments. In line with the general approach of the book there is also a chapter on the practical aspects at all stages of field experimentation. The usual statistical tables together with notes on interpolation and computation are contained in the appendices. As may be expected, not all will agree with the relative proportions of the various sections. For example, more might usefully have been said on the topic of transformations whereas a briefer treatment of correlation would have sufficed, but having regard to the scope of the book such are minor defects. The book is well produced at a very reasonable price.—G.E.H.

REPORT OF THE TECHNICAL MEETING ON POULTRY PRODUCTION IN ASIA AND THE FAR EAST

Food and Agriculture Organisation of the United Nations: Rome, 1956. 123 *pp.*

Winston Churchill once said of international conferences that jaw-jaw is better than war-war. This being so the Food and Agriculture Organisation of the United Nations has, since its inception, done a great deal of good work in promoting a large number of international technical conferences which have greatly assisted in bringing together people with similar problems. Critics of these F.A.O. conferences may be to a certain extent justified in their allegation that they tend to be held a little too frequently, but the criticism that these technical conferences are of little practical value, if true, can hardly be regarded as the fault of the conveners since the practical value of any conference depends entirely upon what the various represented bodies do after the conference is concluded. Some of these F.A.O. meetings have been attended largely by politicians and administrators rather than technicians with an intimate knowledge of the problems involved. As a consequence, the reports of such conferences tend to be idealistic in their recommendations and frequently give no indications as to how the resolutions should be put into effect. Not so the October 1955 Poona conference on poultry production in Asia and the Far East which was attended by several persons who had made notable contributions to poultry production in Asia.

The report opens with a chapter describing the present state of poultry production in Asia, the area from which the domestic fowl is supposed to have originated. This chapter illustrates the present low levels of production prevailing throughout the area and emphasizes the lack of reliable statistics. The chapter dealing with housing and equipment describes in outline primitive methods used in many instances to hatch and raise poultry in Asia. This account includes much of interest particularly the description of the Chinese incubator as used in Malaya.

A long discussion on the improvement of poultry through breeding revealed some further interesting data about present standards of production in various Asian countries, particularly India. Evidence was presented by some delegates to show that the improved breeds of poultry could, in general, be adapted to Asian conditions although the experience in some areas, such as Burma and Singapore, indicated that local breeds had many advantages. The discussion on poultry nutrition emphasizes the lack of organized suppliers of poultry feed throughout Asia, and an extreme paucity of critical information about the value of Asian by-products and herbages in poultry nutrition.

The more important poultry diseases encountered throughout the area and the various methods of their prevention and control were also discussed and various delegates pointed out the measures being taken to prevent and control the more important diseases in their particular areas. However, the report illustrates that in many regions neither much diagnosis nor the control of poultry disease is as yet being undertaken. A discussion on processing, grading and packaging of poultry products in Asia shows that they are in their infancy in this area as in most underdeveloped countries.

The final chapter of this report brings together all the various recommendations of this conference but whether or not the meeting was of any real value in improving the poultry production of Asia and the Far East depends entirely upon what is done by the various governments and organizations represented to implement the recommendations made.—J.R.H.

THE STATE OF FOOD & AGRICULTURE, 1956

Food and Agriculture Organisation of the United Nations: Rome, 1956. viii+143 *pp.* 7*s* 6*d*

The current issue of this annual report on the State of Food and Agriculture has been modified to give emphasis rather on the longer term problems and to present special treatments, such as the factors influencing international trade in agricultural products and a review of general trends for the world's fisheries. Thus half of the publication is devoted to these latter two topics in separate chapters. For most readers the second chapter, world review and outlook, will be the most useful whilst the casual peruser will find Chapter I, which is a summary of the whole work, to contain in succinct and readable form a well considered appraisal of the subject.

The format deserves approval. Printed on quarto size semi-glossy good quality paper, in two columns per page, the text is well documented and appealing. There is a generous assortment of figures, ranging from simple histograms to semi-logarithmic multiple factor curves, and text tables;

the annex tables, anticipating in part the 1956 Yearbook, convey a range of useful up-to-date information.

It is apparent that a vast amount of work has gone into the production of the report and one may assume that the quality of the data presented, by virtue of the experience of the compilers and collaters, has now reached as high a standard as possible. It is however a sad reflection upon the United Nations Charter, which gave birth to F.A.O., that throughout the text data for world production are liable to be redefined as excluding U.S.S.R., China and Eastern Europe.

Of the subject matter itself it may be noted that world food production rose by 3 per cent in 1955–56; there was, however, a continued decline in prices for agricultural products and a further fall in farm incomes in most countries. The largest increases in production were in North America and Oceania; areas, it is noted, that are already the most troubled by surpluses. Livestock production increased more rapidly than that of crops in the more developed countries. Output of most forest products reached record level whilst there was little change regarding fisheries.

During the year under review, a good demand for agricultural products was maintained on the whole with strong consumer demands for foodstuffs and beverages but some easing in the case of rubber and fibres. The actual volume of trade, increasing some 5 per cent, was the highest since the war. Using new figures for the value of international trade, the report shows that some commodities such as coffee, cocoa, bananas and newsprint (a forest product) had increased rapidly in recent years whilst many others such as cereals, meat, cotton and certain fisheries products had shown little change. A discussion of, and reasons for, this are given.

The fall in farm prices was not in general appreciated by the consumer and together with the accumulation of surplus stocks these facts have led to changes in the agricultural policies of a number of countries. The most important new measure to curtail production has been the setting up of a 'Soil Bank' by United States legislation.

In general the present economic situation is likely to continue for the succeeding year.—R.H.F.

MILK AND BUTTERFAT RECORDING

E. D. Ashton. Commonwealth Agricultural Bureaux: Farnham Royal, 1956. 205 *pp.* (illus.) 30*s*

Milk and Butterfat Recording, technical communication No. 3 of the Commonwealth Bureau of Dairy Science and Technology, maintains the high standard of Commonwealth Bureaux publications. Its format is good, the binding is adequate and the information succinct and well arranged. Like most Commonwealth Bureaux publications the literature has been widely used to produce a reference work which anyone can use with confidence.

The book is divided into two parts and contains some useful appendices. Part I deals with milk and butterfat recording as a whole; the development, organization and financing of milk recording is discussed and also the international aspects. A very useful chapter for the dairy worker in the

tropics deals with the estimation of milk and butterfat yields from records; this subject has figured prominently in recent years in dairying literature.

Part II discusses milk recording on a regional basis. From the standpoint of the tropics and sub-tropics, the lack of organization for recording milk and butterfat in the lower latitudes is evident by the little information from the few areas mentioned. The inadequate supply of statistical information from tropical areas is further emphasized in the tabular appendices where the tropical and sub-tropical countries are largely represented by blank columns.

Milk recording is recognized throughout the world as an essential part of dairy husbandry. This reference book therefore should prove useful to many who are striving to improve the efficiency of dairying in their particular area. To tropical workers this subject is all-important because in many areas the stage of development of the dairy industry has reached a level where adequate milk recording is essential to effect further progress. In some tropical areas the dairy industry is as yet not ready for a national recording scheme but individual dairies may be sufficiently developed and interested to adopt ideas mentioned in this book and might ultimately form a starting point for a National Scheme.—J.R.H.

AN INTRODUCTION TO THE BOTANY OF TROPICAL CROPS

L. S. Cobley. Longmans Green: London, 1956. 357 *pp.*(illus.) 37*s* 6*d*

The need for an introductory text-book on the botany of tropical crops has long been felt. Mr Cobley is to be congratulated on his courage in undertaking its writing, and on the degree of success he has attained. As indicated in the preface, he has had the good sense to consult a number of well known specialists in preparing particular chapters.

All the important tropical crops, and a good number of minor ones, are adequately covered. The text consists mostly of descriptions of the external morphology of each species, with some general remarks on certain groups such as the Gramineae and Papilionaceae, and notes of rather unequal length on the distribution, processing, and uses of each crop. Little is said of the genetics, physiology, or ecology of the crops. Forage and fodder crops are omitted on the grounds, as stated in the preface, that they would require another volume of equal size. These remarks are made not in criticism but in explanation to potential readers of the contents of the book; one cannot have everything in a single volume. A short bibliography is given at the end of each chapter as a guide to further reading. The plates reproducing photographs of most of the major crop plants are an outstanding feature of the book and will be most helpful to students, since there is no country in which all of them can be seen in cultivation.

Specialists on particular crops may feel that some details which are of practical importance have been omitted; and there are remarks here and there which will enable them to air their supposedly superior knowledge. To take a small example from the treatment of the genus *Psophocarpus*, an examination of the most recent floras would have shown that at least eight species are recognized rather than the five which Cobley mentions, and that the name *longepedunculatus* is not now favoured for any of them. But this

book is an introduction to the botany of tropical crops; errors seem to have been avoided with remarkable success, and whatever specialists may find to cavil at, teachers will long bless the author for the help which he has brought to them and their students. A rather more serious criticism is that in a botanical work, even at this level, the authority for each specific name used might have been expected to be printed.

It is inevitable that some readers, whose experience lies in different parts of the tropics from the author's, will disagree with some of his inclusions and omissions. His coverage of the most widely-grown tropical crops is so nearly complete, that if a second edition of the book is called for, as it surely will be, Mr Cobley might consider a few additions. Kola and cashew deserve inclusion for the scale of their production; passion fruit, rambutan, and durian are grown on important acreages and so is derris; *Pisum sativum* is surely (if either is to be included) more important in the tropics than *Vicia faba*. These suggestions are made only because the book is likely to become one that will be well known to students for many years.

G.B.M.

Recent Publications of The Imperial College of Tropical Agriculture

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Reprints are available, at varying prices, of articles in the Cacao Research Reports, including the Colour-Illustrated Guide to the Diagnosis of Mineral Deficiencies in Cacao (1945–1951 Report)—Price 5*s* plus postage.

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Flora of Trinidad and Tobago: This Flora, which has been issued irregularly in parts since 1928, is a compilation of the work of many authors. The early parts, mainly by R. O. WILLIAMS, were edited by the Department of Agriculture of Trinidad and Tobago, but since the end of the second world war editing has been taken over by the Botany Department of the Imperial College. The Flora may be obtained either from the Department of Agriculture or from the Imperial College. The following parts have been published :

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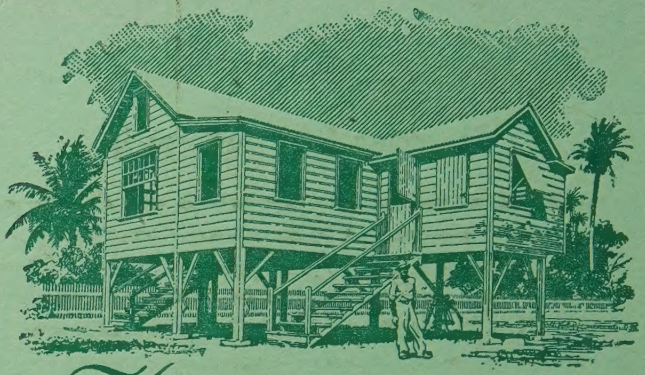

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